CERAMICS

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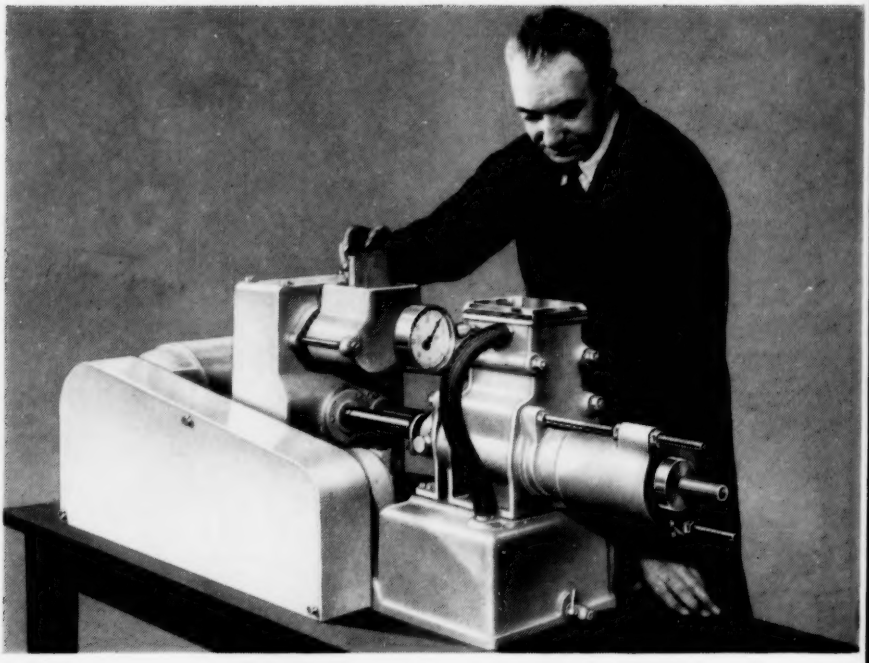

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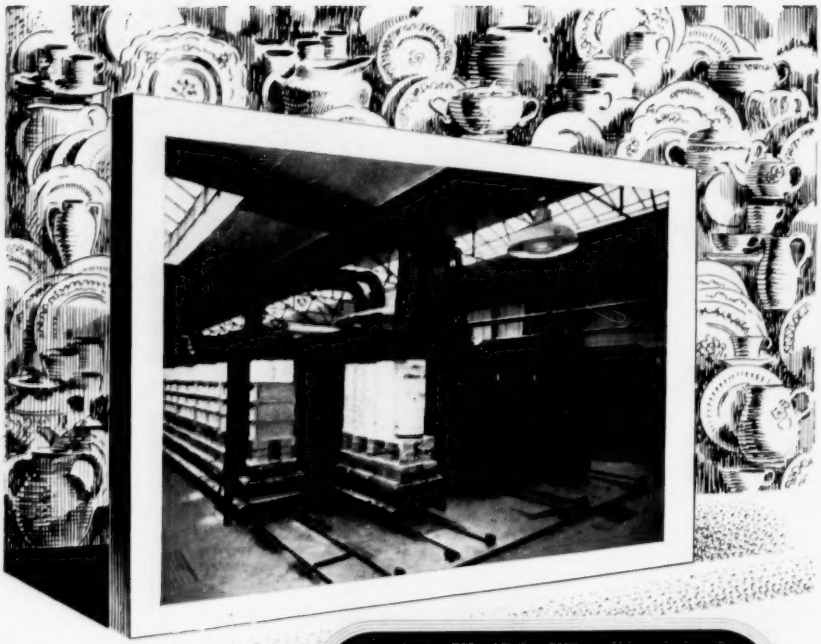

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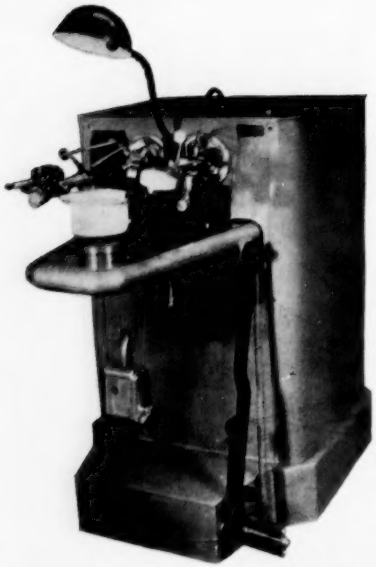

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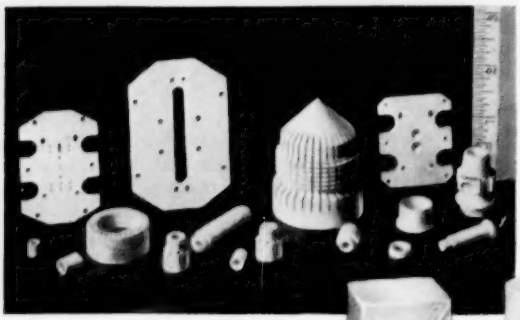

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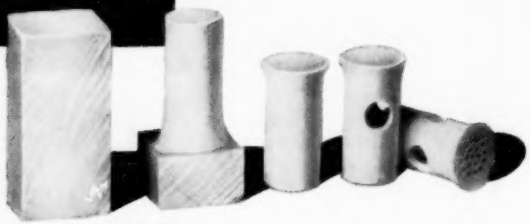

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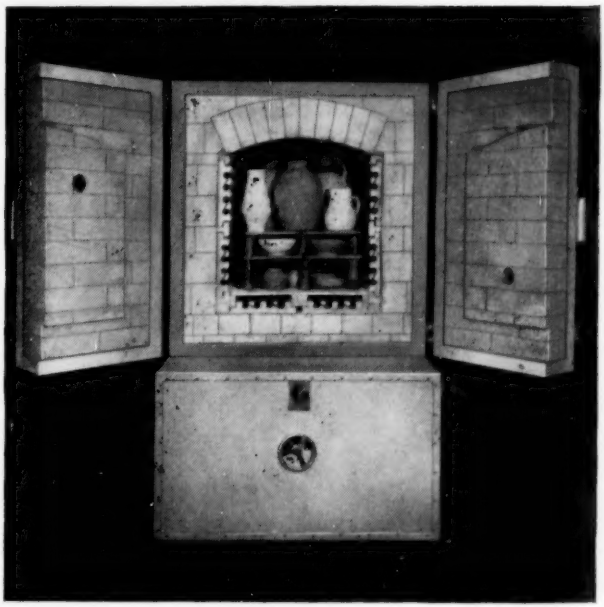

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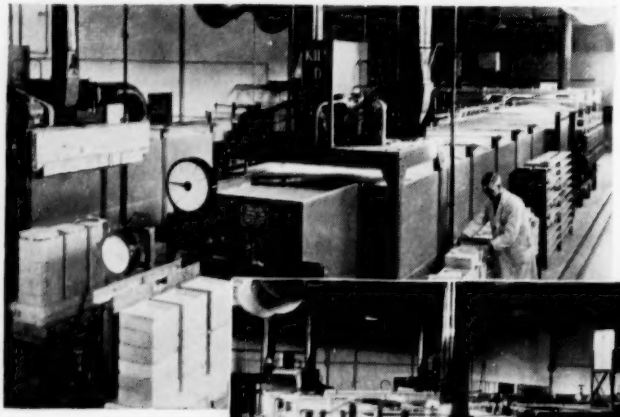

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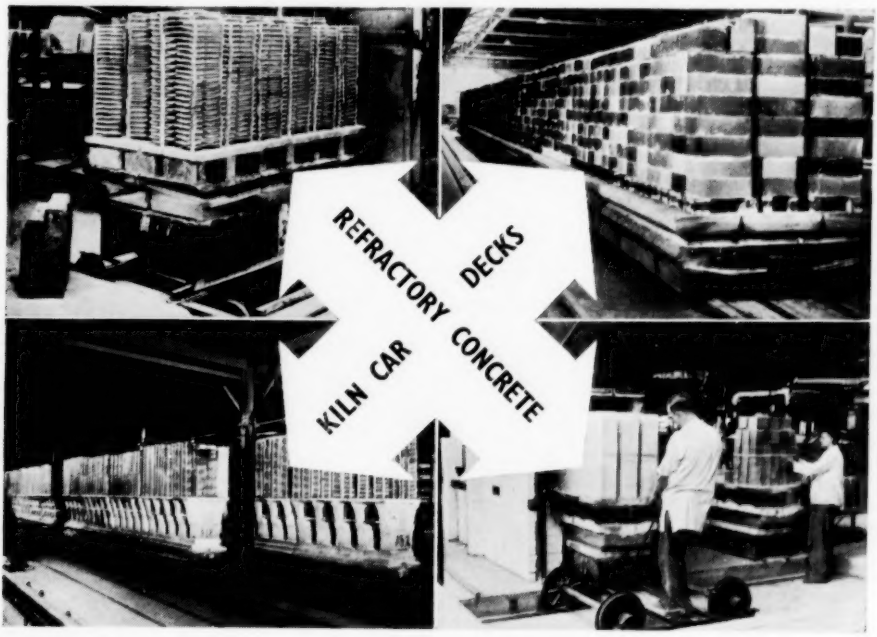

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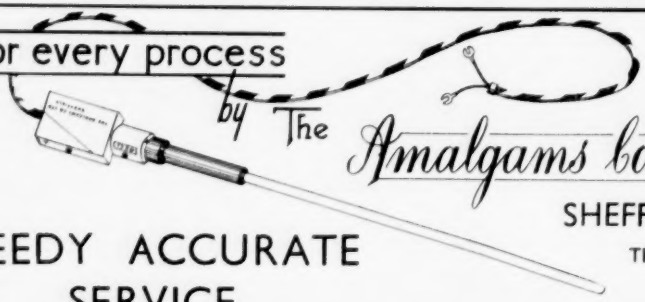

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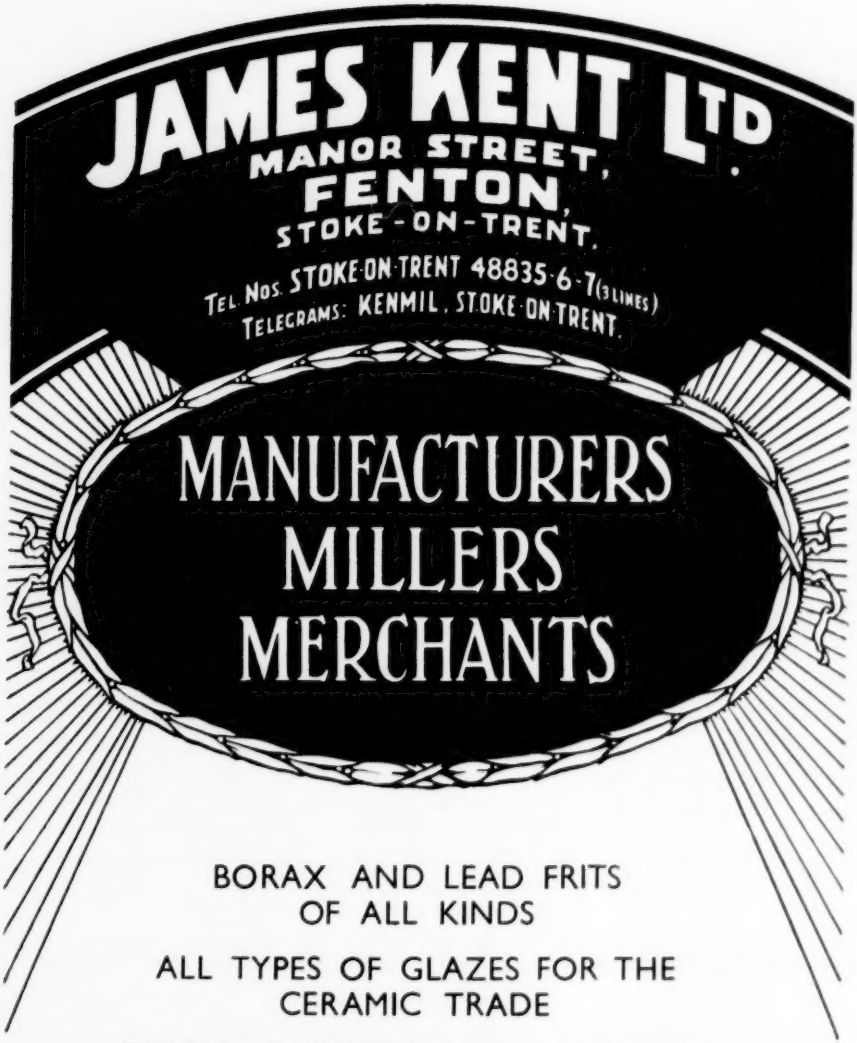

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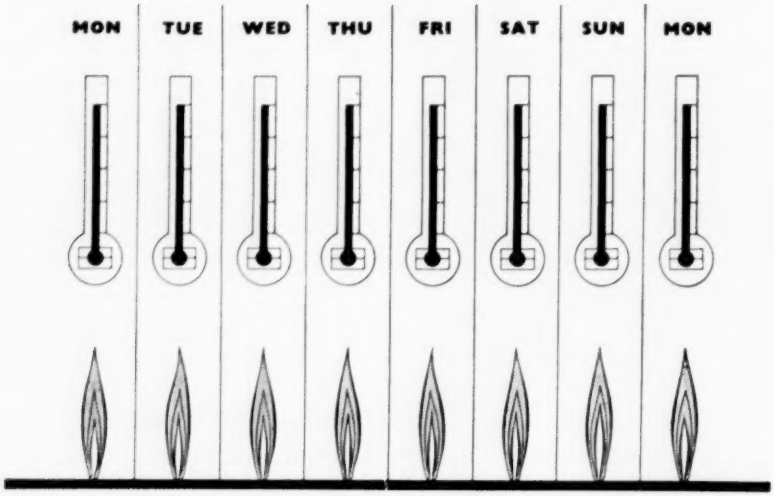

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CERAMICS

A monthly journal covering the pottery, glass, heavy clay, refractory and silicate industries.

OCTOBER 1954

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Ceramics

VOL. VI OCTOBER, 1954 NO. 68

Oil and Ceramics

THE changing world pattern of energy due to oil was outlined recently by Mr. C. M. Vignoles, managing director of Shell-Mex and B.P. Ltd. In 1938, coal provided 64 per cent. of the total world supplies, and oil only 24 per cent. By 1950, oil had risen to 32 per cent. and coal declined to 50 per cent.; whilst in 1953 oil was contributing 35 per cent., natural gas 16 per cent. and coal 42 per cent. However, even in Britain in 1953 only 7 million tons of gas, diesel and fuel oils were use—equivalent in calorific value to some 13 million tons of coal—against 208½ million tons of coal.

However, the oil industry is not, according to Mr. Vignoles, setting out to sell fuel oil indiscriminately. The industry intends to restrict its sales efforts to those industries which will reap the full advantage of the high efficiency of oil utilisation. In these selected industries he included those of glass and ceramics. He thought there was great scope for increased oil fuel usage in ceramics—in the production of pottery, tiles, sanitary ware, salt glaze ware, and high temperature refractories, particularly when tunnel kilns were replacing intermittent firing.

He did not think that oil had marked advantages in the building brick industry because of the large capital investment for a continuous brick kiln which uses relatively low grades of coal. However, in certain isolated instances economic oil-fired brick kilns have been adopted after investigation and experiment.

To the ceramic industry where fuel costs are a relatively high proportion of their over-all production costs the urge from the Minister of Fuel and Power towards greater oil utilisation in industry will be welcome. Already the ceramic industry has faced excessive coal charges—they changed over at great capital expenditure to continuous gas-fired kilns and found the price of their fuel rose steeply. The price of electricity has been too high for its universal adoption except in specialised instances. The vigorous advent of oil, by increasing the scope of competition, might react favourably upon the fuel economies of kiln firing to the advantage of the user.

The Maturing of Glazes and Enamels

SPECIALLY CONTRIBUTED

THE term maturing of a glaze is applied to those processes whereby the ground material which is deposited on the biscuit (or metal in the case of enamels) is converted into a smooth glossy surface. It is a preferable term to melting, since the production of a smooth surface on the glaze or enamel usually implies something more. A glaze can be melted but may be full of bubbles, which can cause pinholes and blisters. These must be removed by further heating, and when this has been done the glaze has been matured, and gives a bright shining surface.

The various stages which occur in producing a glaze during heating are often not realised, and it is instructive either to fire samples to various stages of the process, or to remove them from time to time from a glost oven. It will be seen that the smooth surface is only produced towards the end of the firing, when all gases have been expelled, and the holes made by the bubbles in escaping have healed up. Fig. 1 shows the stages in the production of a black opaque glaze. A knowledge of these is of great assistance in assessing the causes of many of the faults which arrive from time to time in firing glost ware.

Chemical Reaction

Long before melting actually commences chemical decomposition starts with some of the glaze and enamel components. C. W. Parmelee (*Ceramic Glazes*, Chicago, 1948) has tabulated a number of those which are of importance in glazes. Clay begins to give off water mainly around 450° C.

$Al_2O_3\ 2SiO_2\ 2H_2O — Al_2O_3 + 2SiO_2 + 2H_2O$ Whiting (calcium carbonate) dissociates at 886° to 915° C. giving off carbon dioxide. It has been stated that dissociation can start at as low as 610° C. the exact temperature depending on the grain size. Magnesium carbonate dissociates at a similar temperature to whiting (800° to 900° C.). Sodium and potassium carbonates melt at temperatures below 900° C. without decomposition. Boric acid and borax lose water

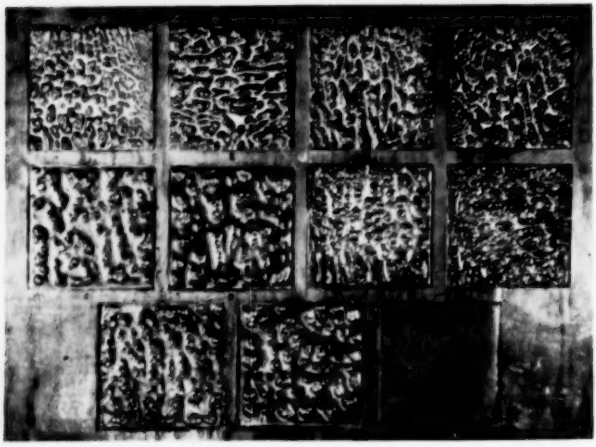


Fig. 1.

Stages in the maturing of a semi-matt black glaze

at comparatively low temperatures. Some of these substances are not used directly in glazes, since they are soluble in water, but they are widely used in making frits, where the dehydration causes "boiling," which is very effective in stirring up the mixture. Red lead Pb_3O_4 melts at 596° C. with decomposition liberating oxygen.

These dissociations may be masked by chemical reactions, some of which can start at comparatively low temperatures. Little is known of the complete reactions which must occur in the formation of the glass, which is to be the final covering known as the glaze. This is a more or less complex mixture of silicates and borates, and alumino silicates and alumino borates and other combinations such as possibly alumino-silico-borates. It is known that calcium and alkali carbonates will react at comparatively low temperatures with silica to produce silicates and carbon dioxide:

e.g., $CaCO_3+SiO_2=CaSiO_3+CO_2$

Lead oxide reacts with silica similarly to form lead silicates $PbO{\cdot}SiO_2$ and $PbO,\ 2SiO_2$.

Reaction Can Occur in Solid State

As in other chemical processes reactions can commence at comparatively low temperatures and proceed slowly until the temperature is raised, when the reaction proceeds at a much quicker rate. The reactions can occur between the solids without melting taking place, though in some cases sintering occurs. Thus the reaction between calcium carbonate and silica can be traced at around 600° C., though a much higher temperature is required for it to proceed at a reasonable speed. Lead oxide and silica begin reacting around the same temperature. These instances are given to show that the chemical reactions may begin comparatively early in the heating process, though there may be little or no visible sign of it.

Melting

It is the melting process that is all important, since the glazing involves covering the article with a layer of molten glass, which will solidify on cooling. Various factors have to be considered in this process. Obviously thorough mixing and fine grinding help melting. Chemical reactions producing substances of low melting point also help. It is, however, the formation of eutectics at comparatively low temperatures that often plays a very important part in the melting process. On account of this it may be well to enlarge on the subject. It is often found that when two refractory substances are heated together melting will occur at a temperature below the melting point of the more infusible member, and in some cases below that of either component. The exact point at which melting commences depends on the proportions in which the two substances are mixed. There is one mixture which has a lower melting point than any other, and this is called the eutectic mixture, and the melting point the eutectic temperature. As an example we may consider two very refractory substances alumina Al_2O_3, and silica SiO_2. The melting point of the former is 2,050° C., and that of the latter 1,710° C. Yet a mixture of these in the proportion, 10 per cent aluminia and 90 per cent. silica (the eutectic) will melt at 1,545° C.

Lead oxide and silica form a number of eutectics such as 98·8 per cent. PbO and 1·2 per cent. silica at 540° C., and another at 661° C. with 60·6 per cent. PbO. Then there is a eutectic of lead oxide, alumina and silica (PbO, 61·2 per cent., SiO_2, 31·7 per cent., Al_2O_3 7·1 per cent.) melting at 650° C. and another of 77·8 per cent. PbO, 5·8 per cent. B_2O_3 and 16·4 per cent SiO_2 melting at 485° C. Felix Singer (*Ceramic Glazes*—Borax Consolidated Ltd. London, 1947) has also tabulated a number of eutectics which are of importance in ceramics.

Eutectics not Compounds

It is important to realise that eutectics are mixtures and not compounds. Molten mixtures outside the composition of the eutectic give separation of one of the components on cooling. The mixture corresponding to the eutectic composition, however, solidifies without separation of one of its components, and

will melt again unchanged. For that reason eutectics were at one time thought to be chemical compounds. Microscopic examination usually reveals crystals of both components intimately mixed in a conglomerate. This and other evidence has disproved the idea that eutectics are chemical compounds.

Gas Formation

We see, therefore, that in the melting state there are unsolved chemical reactions and eutectic formations as well as ordinary melting of some of the components. As soon as a layer of liquid forms on the surface of the glaze layer further gas evolution must involve the formation of bubbles. The gas evolution will involve an escape of air bubbles from air entrained in the powdered glaze and in the biscuit underneath. In the case of metal, gases may be occluded in it as a result of previous manufacturing operations. Chemical reactions involving carbonates will lead to bubbles of carbonic acid gas, and delayed liberation of water from clay and crystals may also cause small amounts of steam to come off.

At this stage the glaze will still be very viscous and the result is that the surface is thrown into a number of rough craters, where gas bubbles have formed in the surface and burst. Provided subsequent heating makes the glaze fluid enough to run in and fill these craters a smooth glaze results. It is the failure to do this that gives some of the usual faults in glost ware, and, provided the processes referred to above are understood, it is often an easy matter to arrive at the cause of the fault.

Pinholes and Similar Faults

It is obvious that if the crater left by a burst bubble does not fill up then a pinhole of variable size will be left. The bubble will normally form as a result of reactions in the glaze. Alternately the odd pinhole is more likely to result from some impurity such as wood, tobacco, or combustible dust of some sort, which in the heating forms carbon dioxide. Pieces of limestone from runners in glaze pans have also been known to cause the trouble due to decomposition giving carbon dioxide in the glost fire:

$$CaCO_3 = CaO + CO_2$$

Glazes which are viscous at the melting point, such as some of the opaque glazes and high melting glazes, are more prone to this fault than some of the more fluid ones used at lower temperatures. With some coloured glazes it sometimes happens that craters get filled with clear glaze but for reasons not understood the colour is left outside. White spots, therefore, appear. This is most likely to happen with chromium pink, manganese brown and some iron brown stains. Nowadays certain glazes are often made from fritted materials in which much of the gas evolution has occurred in making the frit. For this reason such glazes can often be matured in very much shorter times with less risk of pinholes. A frit is in effect a kind of glass, and mixed with a little clay to help in its suspension in water it can be used as a glaze.

Egg-shell

A much more common fault than pinholes is what is known as egg-shell. This describes a glaze in which there are a large number of miniature pores resembling an egg-shell. They arise though the incomplete sealing of holes left in the glaze surface by gas evolution. The cause is usually slight underfiring, though it is conceivable that a certain amount of overfiring would give the same effect due to volatilisation of some of the glaze components. This point can be decided by adding a little china clay to the glaze. This raises the maturing temperature, and hence will aggravate the egg-shelling in the case of underfired ware, and will improve it if overfiring is the cause of the trouble.

Crawling

We have seen that in the maturing process the craters are filled up by fluid molten glaze. Occasionally one comes across cases where the glaze refuses to flow over the underlying biscuit (or metal in the case of enamels). This is due to the fact that surface tension effects prevent the

molten material flowing properly, or possibly in the spraying or dipping operation something has prevented an adequate amount of the glaze or enamel being retained in places. Causes of the latter include dirt and grease on the articles being treated.

Glazes and enamels which have been opacified by additions of refractory oxides like tin oxide, zirconia, antimony oxide, etc. tend to be more than usually viscous in the molten state, and in these the glaze or enamel sometimes collects in heaps or balls, leaving bare patches. This phenomenon is given the general name of crawling. It is a peculiar fact that it often occurs if the dry glazed surface is broken before or in firing, either by excessive shrinkage which follows from the use of very plastic clays in the glaze, or as a result of rough handling. With aqueous solutions it is possible to use wetting agents to reduce the surface tension between the liquid and solid.

At present our knowledge of what can be done to reduce the surface tension between surfaces and molten glazes is very limited. Molybdic oxide has been stated to effect some improvement. With a commercial glass one set of investigators has reported magnesia as the best of the oxides studied in reducing surface tension, followed by ZnO or $\frac{1}{2}Al_2O_3$, CaO or BaO, SiO_2, Li_2O, Na_2O, B_2O_3, K_2O and PbO (A. E. Badger, C. W. Parmelee, and A. E. Williams, *J. Amer. Cer. Soc.*, **20,** 325, 1937).

Crystallisation in Glazes

A glaze is normally smooth and shiny, but under certain conditions crystallisation can occur and the surface is then of a matt texture, or definite crystals appear in it. Sometimes this is done deliberately. A glaze being a supercooled liquid, it is important to cool it quickly to prevent crystallisation. This occurs most rapidly in the temperature region 700° to 850° C., and it is desirable, therefore, that the glaze shall be cooled rapidly through this range when it has been matured. The crystallisation is due to the formation of calcium silicate or zinc silicate, depending on the glaze composition.

The latter can be varied to give crystallisation deliberately when it is desired to produce a matt or similar surface. A simple addition of sufficient whiting or of zinc oxide to a glaze will usually produce a matt effect. Since matt glazes readily pick up dirt however, most manufacturers prefer to use a vellum surface which is smoother and not subject to this drawback. Usually 4 per cent to 5 per cent. additions of each of zinc oxide, titania, and tin oxide to a glaze will give a pleasing vellum surface. Since alumina tends to prevent crystallisation it is kept low in glazes where crystals are desired.

Bearing in mind what has been stated above it is evident that a glaze which is not fully matured may have a matt surface. This, however, is not to be recommended as a way of producing this effect.

It frequently happens that on trying out recipes for crystalline glazes —of which there are many in the literature—the result is a perfectly smooth shiny glaze. The reason for this is that given above, namely that crystallisation proceeds fastest in a certain temperature range, and if cooling through this zone is too rapid then no crystals are formed. For the same reasons it is sometimes difficult to produce matt and semi-matt glazes in tunnel ovens until the firing schedule has been adjusted.

Stresses and Strains Set Up in a Glaze on Cooling

While the glaze is still fluid it can adjust itself to the contraction of the material which it covers. Below about 400° C., however, when it has solidified the movements of the body underneath may result in the glaze being compressed or extended depending on the relative expansions of these materials. Should the body contract more than the glaze then the latter is compressed and if the compression is greater than the mechanical strength of the glaze it may crack and shear off. In actual practice this is infrequent, since manufacturers have learnt to adjust the composition and maturing of the glaze. Some compression of the latter is desirable to avoid crazing, and

(*Continued on page* 359)

The Use of Titanium Oxide in Vitreous Enamels

SPECIALLY CONTRIBUTED

ALTHOUGH a patent was granted in 1893 covering the use of titanium oxide in vitreous enamels it was not until 1920 that TiO_2 became generally recognised as a beneficial ingredient in acid resisting enamels.

Research into the behaviour of TiO_2 in vitreous enamels led to the inception of the recrystallisation technique which facilitates the production of super opaque acid resistant enamels.[1] During the past 15 years the technique has become increasingly popular and today nearly all white and pastel shade enamels for holloware, etc., are dependent upon TiO_2 for their opacity, acid resistance and superior mechanical properties. Apart from this specific application TiO_2 is an important ingredient in most high quality enamels for cast iron and aluminium, etc.

Development of Manufacture of Titanium Oxide

Titanium oxide is an extremely powerful, non-toxic, white pigment of very fine particle size. It is manufactured in two crystal forms, anatase and rutile, the former being the type normally used in vitreous enamels. The two forms have the same chemical composition, TiO_2, but differ in crystal structure. In this connection, the use of the word rutile must not be confused with the mineral Rutile which, although containing a high percentage of TiO_2, is unsuitable for use in white vitreous enamels or for pigment manufacture.

The most important titanium ore is ilmenite, a black titaniferous mineral which comprises roughly 55 per cent. TiO_2, the remainder being largely FeO and Fe_2O_3 with small amounts of silica, magnesium, manganese, chromium, phosphorus, zirconium, vanadium and often traces of rare earths.

The sulphuric acid process of extracting titanium oxides from ilmenite was in use both in Norway and in North America in 1918 and much the same process is, with modifications, still in use today.

The information contained in this article has been made available to us by British Titan Products Co. Ltd., whose assistance we wish to acknowledge.

Manufacture of Titanium Oxide

The ilmenite is dried and finely ground, then digested with concentrated sulphuric acid—a violent reaction which results in a solid cake of mixed titanium and iron sulphates. This cake is dissolved in water and, after clarification, the resulting liquor—titanium sulphate—is cooled, whereupon some of the iron sulphate crystallises out yielding an important by-product—green copperas, which, incidentally, is used in the preparation of iron oxide colours, fertilisers and in effluent clarification. The titanium sulphate is separated from the copperas and hydrolysed. Next, the complex hydrated oxide is filtered and washed. Finally, the washed pulp is calcined and ground to give pigmentary titanium oxide.

Properties of Titanium Oxide Anatase E and HR for Vitreous Enamels

Crystal structure Anatase; Mean particle dia. ca. 0·2μ; Residue on 325 mesh 0·05 per cent. max.; Mean Refractive index 2·55; Specific gravity 3·9.

Typical Analysis: TiO_2 98·5; ZnO 0·02; Al_2O_3 0·10; P_2O_5 0·4; Soluble salts 0·4; Moisture 0·4; FeO 50 ppm.

Advantages of TiO_2 Self Opacified Enamels

In properly formulated enamels, the high refractive index of TiO_2, together with its small particle size on recrystallisation, gives complete opacity in one coat at an application weight of about 25 gm./sq. ft., dried slip over the conventional cobalt bearing groundcoat. This thin coat has superior thermal and mechanical shock resistance when compared with tin or antimony oxide opacified enamels which need to be about three times as thick to give equivalent opacity. The reflectance of self-opacified titania enamels is 80 per cent. or higher, and the tone can be varied from a blue white to a cream white at will.[2] (See Fig. 1).

Another advantage of TiO_2 is that its incorporation into an enamel considerably increases the acid resistance of the finish without unduly affecting its viscosity, smelting or firing temperature. The scratch resistance is also superior to that of the older finishes.[3]

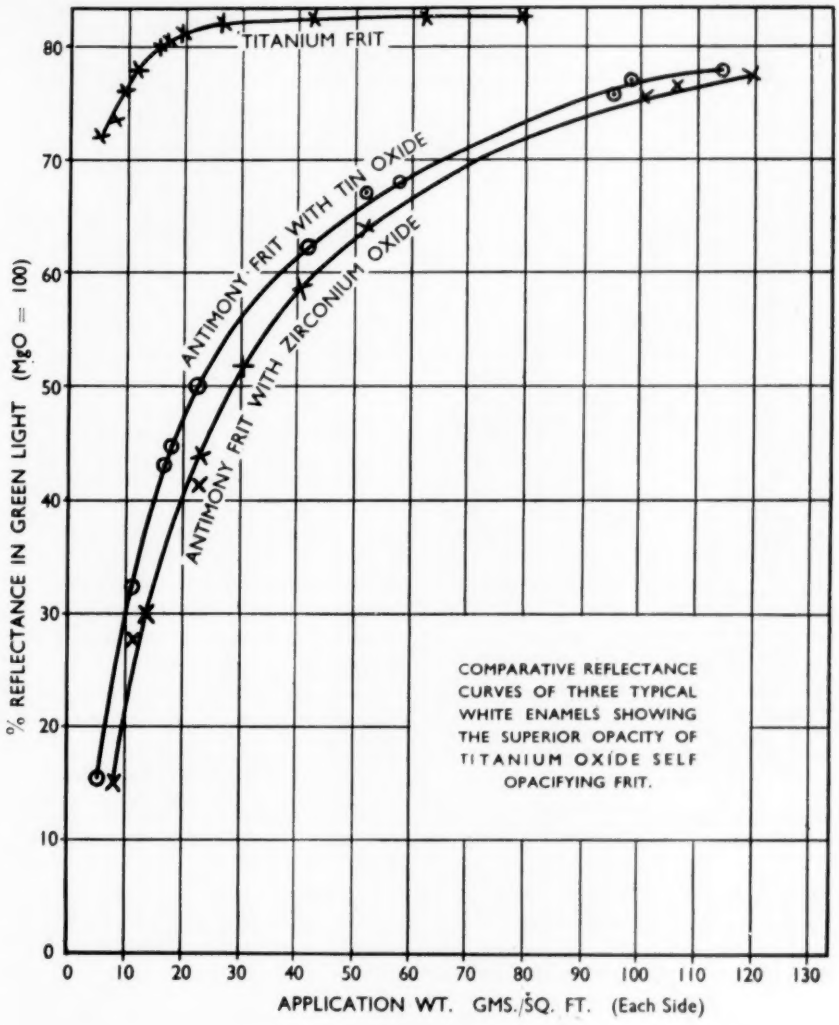


Fig. 1

Two of the early difficulties associated with the use of TiO_2 in steel enamels were:

(a) The expansion of enamels formulated to give the best colour and brightness was too small and distortion of the ware frequently occurred.

(b) When used with colouring oxides at the mill the fired colour varied from batch to batch, i.e., the enamels were critical of firing conditions.

The first of these disadvantages has been eliminated by the incorporation of lithium[4] and by adjustments to the enamel composition.[5] The second has also been overcome by ensuring that the recrystallised TiO_2 is in the anatase modification,[6] by incorporating phosphates in the batch[7] and by keeping the firing time/temperature at a minimum.

Mechanism of Self-opacification

The enamel composition is so formulated that all the TiO_2 dissolves in the rest of the glass during the smelting operation which is carried out at about 1,200° C. The batch-free smelt is then quenched in water to yield a pale coloured frit. The

TABLE 1.

Mill Addition (per cent. on frit)

Frit number	*2155*	*231*	*M9*	*1033*	*814*	*1536*
Pipe clay	5	5	5	—	5	3
Bentonite	½	—	½	—	—	½
Sodium aluminate	¼	¼	¼	—	¼	—
Potassium nitrate	¼	¼	¼	—	¼	—
Colour oxide	—	0-5	—	0-5	—	—
Titanium oxide	0-2	—	—	—	5	—
Black oxide	—	—	—	—	—	4
Borax	—	—	—	—	—	½

quenching operation is primarily to maintain the TiO_2 in supersaturated solution, but it does also facilitate subsequent milling of the frit. When the frit is reheated at the lower firing temperature (ca. 800° C.) only a portion of the TiO_2 remains dissolved in the glass; the rest crystallises out as small discrete particles. It is this recrystallised titania which provides opacity whilst the acid resistance is primarily determined by the TiO_2 remaining in solution in the glass.

The crystals of titanium oxide may be anatase or rutile or a mixture of the two and the crystal form is determined by the frit composition, which, together with the firing time/temperature, also fixes the size of the TiO_2 and hence its opacifying power.

Factors Controlling the Form of the Recrystallised Titania

For the popular bright clean toned enamels having good colour stability to firing changes, the TiO_2 should be in the anatase modification. This is obtained by:

1. Keeping the alkalis at a minimum.
2. Increasing the silica or alumina and hence the viscosity.
3. Incorporating P_2O_5 in the batch—approximately 2 per cent. on the melted composition is usually sufficient.
4. Thorough mixing of the enamel batch to ensure homogeneous TiO_2 distribution throughout the batch.
5. Smelting and firing under non-reducing conditions. (If reducing conditions exist in the smelting process the frit will be dark brown in colour).
6. Smelting until it is completely batch free.
7. Quenching the frit rapidly and uniformly as soon as it is batch free, to prevent premature TiO_2 recrystallisation at this stage.
8. Firing for the minimum time/temperature consistent with satisfactory flow, gloss, etc.

A formulation which yields a bright, white, colour stable, self-opacified enamel for use on sheet iron and steel is frit 2155.

General Notes on Mill Additions

The recommended mill additions† for titanium self-opacified enamels are:

1. *Suspending Agents*

3 to 6 per cent. pipe clay alone or in conjunction with 0 to ½ per cent. bentonite.

2. *Colour and Brightness Improvers*

¼ per cent. potassium nitrate, ½ magnesium carbonate, ¼ to ½ per cent. sodium aluminate, 1 to 2 per cent. titanium oxide.

3. *Electrolyte*

Any of the usual electrolytes may be used to "set-up" the slip, e.g., sodium nitrate, borax, potassium chloride, etc.

Other mill additions[5] such as urea, methyl cellulose, gum arabic, etc., have also been described and are useful to a limited extent as suspending agents or to improve biscuit strength. The use of a sodium silicate/sodium aluminate gel to suspend the frit has been patented.[5]

4. *Fineness of Grind*

The opacity of titania self-opacified enamels is practically unaffected by the degree of grinding of the slip although the extremes should be avoided, very coarse grinding resulting in an uneven surface and very fine grinding tending to cause tearing. Satisfactory limits are between 10 per cent. residue on 180 mesh to 1 per cent. on 325 mesh.

† *See Table* 1 *for per cent. on frit mill additions.*

Application Weight

The graph of application weight of a typical TiO_2 self-opacified enamel, against brightness and colour index (Fig. 2), shows that the optimum results are given by an application of 25 to 30 gm./sq. ft. dried slip. Excessive amounts can cause a decrease in thermal and mechanical shock resistance.

Effect on Frit Constituents on the Properties of Self-Opacifying Titanium Enamels

1. *Increase in Alkali (Na_2O, K_2O, Li_2O)*
Increases expansion and workability but decreases acid resistance, brightness and anatase content. The colour becomes more cream and a lower firing temperature is possible.

2. *Increase in Silica*
The anatase content, blue tone, acid resistance and viscosity increase and the coefficient of expansion decreases. A high firing temperature is usually required.

3. *Increase in Boric Oxide*
Acid resistance, coefficient of expansion and opacity decrease. There is little effect on anatase content. At upper limit of B_2O_3 content the gloss deteriorates.

4. *Increase in Alumina*
There is little change in anatase content. The expansion increases and the gloss decreases. The solubility of TiO_2 in the frit decreases, i.e., more recrystallises on firing.

5. *Calcium Oxide or Fluoride*
These compounds have a deleterious effect on colour.

6. *Antimony Oxide*
The colour is adversely affected—a dirty green tone being formed.

7. *Fluorine*
As the fluorine content decreases so the brightness and acid resistance increase. Working properties are improved by incorporating fluorides.

8 *Zinc Oxide; Magnesium Oxide*
These oxides improve the brightness of the fired enamel and also decrease the blue tone. MgO is more effective in this respect than ZnO.

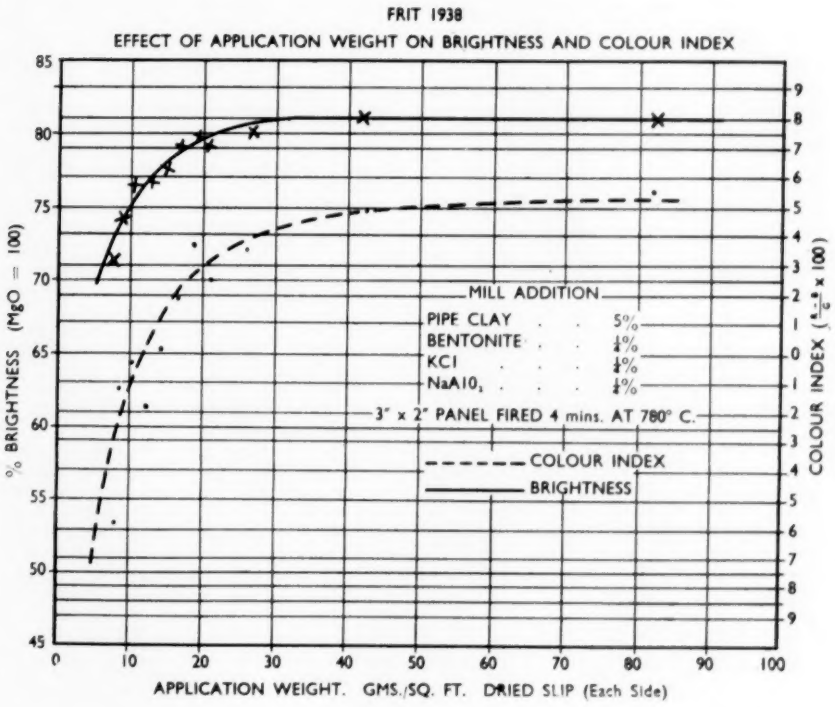

FRIT 1938
EFFECT OF APPLICATION WEIGHT ON BRIGHTNESS AND COLOUR INDEX
% BRIGHTNESS (MgO = 100)
COLOUR INDEX ($\frac{L-B}{2}$ x 100)
APPLICATION WEIGHT. GMS./SQ. FT. DRIED SLIP (Each Side)
MILL ADDITION
PIPE CLAY . . 5%
BENTONITE . . ¼%
KCl . . . ¼%
$NaAlO_2$ . . . ¼%
3" x 2" PANEL FIRED 4 mins. AT 780° C.
COLOUR INDEX
BRIGHTNESS

Fig. 2

9. *Phosphorus Pentoxide*

The anatase content and blue tone increase on incorporating P_2O_5. The colour stability to firing changes is improved.

Dry Process Cast Iron Enamels

Titania is incorporated into this class of enamel primarily to improve acid resistance although the expansion coefficient is increased by a partial silica/titania replacement. The opacity is often provided by antimony oxide which remains undissolved in the smelting process.

Frit 1033 is an example of an acid resisting dry process enamel. This type of frit must not be oversmelted or overfired otherwise a serious decrease in opacity occurs. As with steel enamels, a non-reducing atmosphere is required.

Effect of Variation in the Composition of Dry Process Antimony/Titanium Enamels

1. *Alkali*

An increase lowers the smelting and firing temperature but acid resistance and opacity decrease. The replacement of Na_2O by K_2O or Li_2O gives a more neutral white. The expansion increases on increasing the alkali content.

2. *Silica*

Decreasing the silica softens the enamel but the tone becomes creamier and the acid resistance decreases. The expansion increases.

3. *Fluorine*

Fluorine must be present in this type of frit to ensure good colour and gloss, but excessive amounts have a deleterious effect on acid resistance.

4. *Boric Oxide*

As the B_2O_3 increases so the fired enamel becomes whiter and brighter but gloss deteriorates. Acid resistance and expansion also decrease. Enamels low in B_2O_3 are prone to boiling troubles.

5. *Titanium Oxide*

For good opacity the optimum Sb_2O_3/TiO_2 ratio appears to be 1/2. Higher TiO_2 contents cause opacity to decrease and the cream tone to increase. Acid resistance is proportional to TiO_2 provided the other ingredients are unchanged.

6. *Antimony Oxide*

Increasing the Sb_2O_3 increases the opacity and has little effect on tone.

7. *Lead Oxide*

This ingredient lowers the firing temperature but induces a cream tone.

8. *Barium Oxide*

The omission of barium from the formula causes a decrease in opacity and an increase in cream tone.

Wet Process Cast Iron Enamels

This class of enamel is usually of the Sb_2O_3/TiO_2 type although investigations are proceeding into the utilisation of the self-opacifying TiO_2 enamels. These wet process finishes are similar in composition to those applied by the dry process in that the titania is present primarily to ensure acid resistance, the opacity being obtained from the antimony oxide with perhaps additional opacifiers at the mill.

The effect of frit ingredient on brightness, tone, corrosion, resistance, etc., is the same as given for the dry process enamels.

Titanium Oxide in Coloured Enamels

Ceramic colouring oxides may be incorporated into titanium bearing, acid resisting enamels to produce pastel shades or quite strong deep colours. Frit 2155 is a suitable base for stable pastel shades whilst frit 231—a clear acid resistant sheet steel enamel is suitable for the deeper colours. Recent unpublished work carried out at British Titan Products Co. Ltd., on self-coloured enamels has shown that pleasing colours having good stability to firing changes result from smelting in a frit such as 2155, various colouring oxides. Suitable oxides are those of copper, nickel, manganese, cobalt, chromium, etc., or mixtures of such elements. Published information on coloured titanium enamels is also available.[7, 10].

Factors influencing the change in colour by variations in firing conditions include anatase/rutile transformation, crystal growth, chemical reaction between the TiO_2 and the colour oxide, and the entry of colouring ions into the titania lattice causing a change in the valency state of the titanium with a resultant change in tone.

Super Acid Resistant Enamels for Chemical Plant

Enamels which must withstand corrosive chemicals approach the composition of glass, and such enamelled vessels are often called glass-lined. These enamels may contain up to 65 per cent. or 70 per cent. silica and this, together with the low content of alkaline fluxes, makes for an enamel of low expansion and fusibility. The use of titania as a partial replacement for silica overcomes these disadvantages in that there is no reduction in acid resistance but the enamel is more fluid and has a higher expansion.

Frit M.9 is a super acid resistant enamel of this type.

Black Enamels

The use of titania in improving acid resistance is utilised in the formulation of many black enamels. The amount of TiO_2 incorporated is such that none recrystallises on firing. Frit 1536 is an example for application to sheet iron and steel.

As with white enamels, so it is with blacks, that variations in the frit composition cause change in tone as well as in acid resistance, expansion, etc.

The more common constituent variations together with the accompanying colour range may be listed as given in Table 3.

Specialised Uses of Titanium Oxide in Vitreous Enamels

1. *Enamels for Aluminium and its Alloys*

There has been a considerable amount of patent literature describing the formulation of vitreous enamels for application to aluminium and its alloys and in many of these formulæ titania has been incorporated to confer opacity and whiteness. The acid resistance of aluminium

TABLE 2.

Frit Formulation.

Frit Number	2155	231	M9	1033	814	1536
Type of Enamel	Super opaque white for sheet iron/steel	Clear AR steel enamel	Super AR for chemical plant	Dry process AR cast iron	Wet process cast iron	AR black for sheet iron/steel
Smelting Temp. °C.	1200+	1100-1200	1150-1200	1050-1100	1050-1100	1100-1150
Firing Temp. °C.	820-840	800-850	850	800	740	820
Batch Compostion						
Feispar	9·2	28·0				
Borax (hydrated)	24·1	22·0	2·6	24·0	14·2	21·9
Quartz	33·4	25·0	19·2	29·4	37·6	37·8
Titanium oxide	15·6	8·5	15·3	10·2	7·8	9·9
Cryolite	2·7				7·9	
Potassium nitrate	9·3			8·2	4·8	10·9
Zinc oxide	1·0			2·0		
Magnesium carbonate	0·7					
*Pot. monohydrogen phosphate	4·0					
Sodium silicate			51·3			
Sodium aluminate			5·3			
Whiting			2·2			
Fluorspar			3·0	3·8		
Soda ash		6·5		5·5	8·6	4·4
Sodium nitrate		7·0	1·1	8·0	9·1	6·5
Calcium carbonate					4·6	
Antimony oxide				5·1	5·4	
Sodium silico fluoride		3·0				3·6
Black cobalt oxide						0·7
Manganese dioxide						1·4
Chrome iron ore						2·9
Barium carbonate				3·8		
Total	100·0	100·0	100·0	100·0	100·0	100·0

**This K_2HPO_4 can be replaced by a sodium or ammonium phosphate on an equal P_2O_5 basis, making due allowances for the potassium and sodium contents.*

TABLE 3.

Alteration to batch	*Colour change*	*Effect on Acid Resistance*
Increase Na_2O	Darkens considerably	Deterioration
,, K_2O	Darkens	,,
,, F_2	Negligible effect	,,
,, B_2O_3	Turns bluer and lighter	,,
Decrease SiO_2	Slight darkening	,,
,, B_2O_3	Considerable darkening	Improvement
Replace some Na_2O by K_2O	Slight lightening	Little effect
,, ,, K_2O by Na_2O	Slight darkening	,,
,, ,, SiO_2 by TiO_2	Slight darkening	Slight improvement
,, ,, TiO_2 by SiO_2	Slight lightening	Slight deterioration
Increase CoO	Increases blue tone	Negligible
,, MnO_2	Increases pinkish tone	,,
,, Fe_2O_3	Increases brown tone	,,
,, Cr_2O_3	Increases brown green tone	,,

enamels is usually poor because of the large amount of flux required to enable the enamel to fire out below the softening point of the base.

B.P. 580, 688 quotes a suitable formula as:

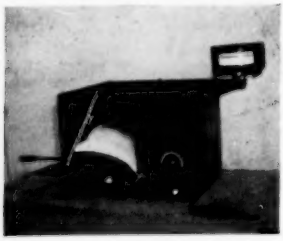
Red Lead	20·8
Silica	27·1
Sodium Carbonate	16·2
Lithium Carbonate ...	5·7
Potassium Carbonate ...	12·5
Boric Acid	8·3
Titanium Oxide	9·4
	100·0

2. *Zinc Titanate Enamels*

This class of finish has quite good opacity and brightness but is deficient in acid resistance. As the name suggests, the actual opacifier is a combination of zinc oxide and titanium oxide, 15 to 20 per cent. of each being present in the batch composition. One advantage of this type of enamel is that it possesses good colour stability to changes in firing time/temperature because of the absence of any anatase/rutile transformation.

3. *Borax Substitute*

During the war a sodium titanosilicate (V.26) was developed in Germany to replace borax as an enamel ingredient. Although good results were claimed it is doubted whether they were up to the standard of the corresponding borax containing frits. According to B.I.O.S. final report No. 944, Item 22, V.26 was made by smelting the following batch at



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Titanium Oxide	31·0
Fluorspar	3·0
Sodium Nitrate	2·3
Sodium Silico Fluoride ...	2·0
	100·0

It is known that sodium titano-silicate is a very mobile liquid at the smelting temperature and it is this fact which is utilised when titania is incorporated into an enamel to improve the acid resistance without the attendant viscosity increase which would result from a similar increase in the silica content of the frit.

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THE MATURING OF GLAZES AND ENAMELS.—(*Continued from p.* 351.) is usually arranged. Where the contraction of the body is less than that of the glaze, the latter tends to be pulled apart, or as we say is thrown into tension. If the tension is sufficiently great then crazing appears. It has been found that when a glaze is properly matured so that a good intermediate (or buffer) layer is formed between glaze and body the risk of crazing is diminished.

CERAMIC ABSTRACTS

The following abstracts have been made from unpublished reports by the Technical Information and Documents Unit of the Department of Scientific and Industrial Research.

Injection Moulding of L-5 Ceramics. Final Report

The first part of the report gives a detailed account of materials, processing and injection results obtained in the last period of the investigation. The most promising factor was the use of finely divided ethyl cellulose flake with the addition of plasticisers being made after incorporation of the resin with steatite base. The second part gives a review of the whole project and conclusions, and lists the materials from which best results were obtained. Recommendations are given. *Stupakoff Ceramic and Manufacturing Co.* April, 1949. 75 pages. R. E. Stark.

Injection Moulding of L-5 Ceramics: Final Report Supplement

Three types of ceramic binder combinations were investigated: ceramic-organic binder-water; ceramic-wax emulsion; ceramic-resin-plasticiser. The formulation alumina—10 microns, 77·9 per cent, Sierra talc, 4·1 per cent.—ethyl cellulose flake, 7 per cent.—shellac, 6 per cent.—butyl stearate, met the specifications required. *Stupakoff Ceramic and Manufacturing Co.* January, 1950. 22 pages. R. E. Stark.

Automatic Pressing of Steatite and Allied Ceramic Bodies

Details are given of a wet-pressing composition based on stearic acid and di-ethylene glycol and a wax composition containing ceremul wax emulsion as satisfactory ceramics bodies which have adequate plastic flow and good strength in the pressing operation and which do not adhere to the mould die. *Office of Technical Services, Washington.* 1953. 2 pages.

Prizes for Ceramic Research.—The annual report of the general council of the British Ceramic Society announces that the society has decided to offer two prizes of £25 and £15 for the two best papers submitted on any subject of ceramic research, carried out primarily at the North Staffordshire Technical College by ceramic students. The report stated that successful papers, undertaken independently or jointly by students, would be read and discussed at a special meeting of the society.

All Made from Glass Fibres

From Textiles to Yachts

FIBROUS glass in textile form has been available in Great Britain since 1938 and has found important uses in many industries. Although glass fibres were known to the ancient Egyptians, who made drinking vessels by the spiral winding of glass threads, it was not until the economic large-scale production of fine glass filaments just before the last World War that the possibilities of this flexible glass in product design became apparent.

Types of Fibre Yarn

Glass fibre yarns are made today in two distinct forms—continuous filament, which has a silky smooth appearance, and staple filament, a discontinuous yarn which is rather hairy like worsted. We are concerned here with the first of these which is the more important product at present. It is made from silica, modified by alumina, borax and other ingredients to improve the weathering resistance and lower the melting point of the glass to help in the formation of fibre. This mixture is melted in a large furnace and formed into marbles. As marbles the glass can be most conveniently fed automatically into the fibre forming process.

Manufacture of Continuous Filaments

The continuous filaments, which are made in three different sizes with diameters of ·00021 in., ·00028 in. and ·00035 in., are drawn from a rare metal, electrically heated crucible, having either 102 or 204 drawing nozzles in the base. The emerging molten glass thus produces one filament from each nozzle. The filaments are gathered together at a V-shaped pad, where they are lubricated by a special size, and are passed downward

Glass fibre continuous filaments are drawn by melting glass marbles and feeding the molten glass into a rare metal, electrically heated crucible. The crucible has 102 or 204 nozzles in the base through which the molten glass flows. Filaments are drawn from each of these nozzles on to a high-speed spindle at about 60 miles an hour. One glass marble produces about 100 miles of single filament.

(Photo by courtesy of Fibreglass Ltd.)

The individual strands of glass filament, after forming and winding into "cakes," are transferred to normal textile spinning frames, where they are twisted and doubled into yarn for subsequent weaving into cloth and tape

(Photo by courtesy of Fibreglass Ltd.)

to a high-speed spindle and wound at a speed of over 60 m.p.h. The wound strands of filament are then twisted and doubled into yarn, and woven in the ordinary way into cloth. Glass fibre textiles provide an inorganic fabric with excellent heat resistance, high tensile strength, very good electrical properties, low moisture absorption and good chemical resistance. Glass filaments, however, do not combine well together, and unless the fabric has been specially treated, their abrasion resistance is lower than the more commonly used organic fibres.

Addition of Polyester Resins

During the post-war period a new and exciting use of glass fabrics has been developed—glass fibre reinforced plastics. The aircraft industry first married the high tensile strength of glass filaments to the easy moulding properties of the polyester group of resins, and produced a new structural material as strong as steel and lighter than aluminium.

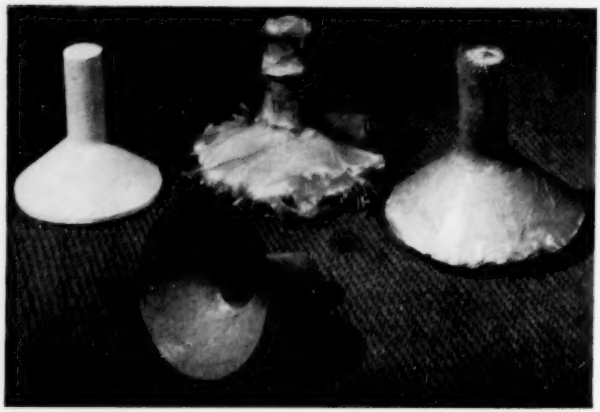
Glass fibre used to reinforce plastics can offer very great advantages to designers in industry, because it gives plastics for the first time two tremendous gains—shell strength, and the ability to be formed at low pressures. No longer must the advantages of plastic materials be confined to small articles needing comparatively little strength, for the development of reinforced plastics makes it possible to contemplate moulded structures up to 100 ft. in length and of immense strength.

Heat and Pressure Unnecessary

Glass fibre polyester mouldings can be made without any external source of heat or pressure, although hot curing resins and matched pressure moulding tools are often desirable to speed up the manufacturing process and, in some cases, to improve the physical properties of the article. Other resins like the epoxides, melamines and silicones are also used to give special properties, whilst the development of low pressure phenolics may well help to bring down costs—an important aspect of the future development of this new structural material.

Great Strength

When polyester resins are used as the bonding agent in a glass cloth laminate, typical test results show a tensile strength of approximately 30,000 lb./sq. in., a cross-breaking strength above 35,000 lb./sq. in. and impact resistance (Izod, edgwise, notched) of 10 ft. lb.; whilst, with a



Acid-pouring funnel made from Bakeite reinforced plastics. This picture shows the easy stage of building up a structure with these materials. (1) A plaster former has been adopted. (2) Conveniently cut strips of glass cloth are laid on this. (3) The glass cloth is impregnated with Bakelite polyester resin. (4) After allowing the resin to harden at room temperature the finished funnel is removed from the mould and trimmed.

undirectional cloth, these figures can be more than doubled. In addition, the strength-to-weight ratio of such a material is exceptionally high.

Material for Car Bodies

It is in this form, as a low-pressure laminate, that polyester resins have recently caused something of a sensation. Having been employed for some time in the construction of boats—where their resistance to corrosion can virtually eliminate traditional maintenance work—they have in the past year leapt into the news as materials for building car bodies, and the main reason for this is the ease with which they can be fabricated without costly plant. To produce any kind of shaped structure, for example, the first requirement is a mould, and, this can be made simply and cheaply from such materials as light sheet metal, plaster or wood, only the male or the female section, not both, being required.

This done, the fibre, in the form of mat, rovings or woven fabric, is next cut into easily handled segments, which are laid up one by one on the mould, each lamination being thoroughly impregnated with catalysed resin. The lay-up thus achieved is then left for a short period in order that the resin may harden, and, at this stage, the application of heat, though not essential, will diminish the time required. When completely cured, the structure is removed from the mould and needs only final trimming to complete it. At the same time any other fittings can be installed by bonding them into position with further strips of fabric and resin, and repairs can be carried out in a similar fashion.

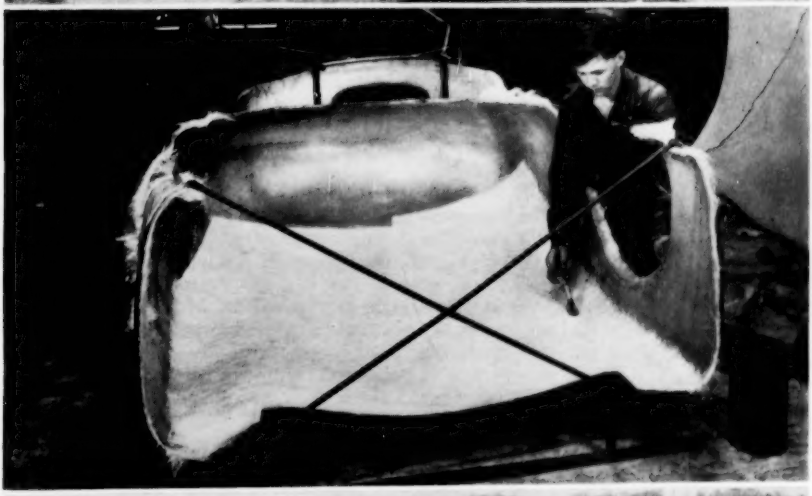
At present, however, the use of reinforced plastics must be confined to relatively small-scale production models, though the development of high-speed production techniques cannot be long delayed. There is, of course, much greater scope for designers with this new material, since it can be easily moulded into compound shapes that would be impossible with metal pressings.

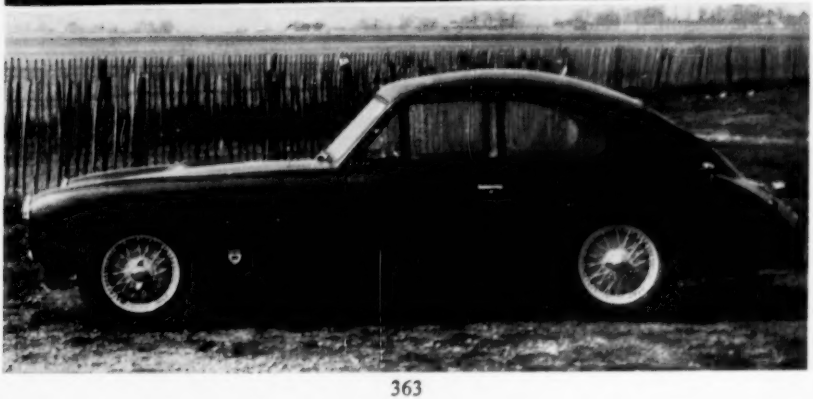
Other Uses of Glass Fibred Plastics

Whilst various precautions are necessary in the course of such work, this remains the essence of reinforced plastics construction, and it will be seen that the materials lend themselves readily to the fabrication of all kinds of strong, light-weight structures. Chemical tanks, aircraft cowlings and radomes, shatterproof roof lighting and partitions, machine housings, cases and covers are but a few which come immediately to mind, suggesting their wide potential range, and the

Facing page: Top: Making a car body from glass fibres and Bakelite polyester resin in the works of the North-East Coast Yacht Building and Engineering Co. Ltd., Blyth. The glass fibre mat is cut to pattern. Centre: Successive layers of glass fibre mat are laid up in the mould and impregnated with Bakelite polyester resin. Bottom: A completed saloon car moulded from glass fibre mat and fitted to an M.G. chassis and engine.

(Photos by courtesy of Bakelite Ltd.)





construction of press-tools would appear to offer another fertile field. Since car bodies have hit the public's imagination, however, it may be as well to state that there is at this stage no suggestion that the materials can replace conventional mass-production methods in this field. The time required to fabricate with them is far longer than that required for pressing metal panels, and material costs are usually higher. The standard car is, therefore, unlikely to be affected by their introduction for a considerable time. Construction in reinforced plastics does, however, compare favourably with panel beating, and for limited runs, such as special bodies, where costly tooling is uneconomical, they, therefore, provide an admirable medium. Other advantages which they offer, in addition to immunity from corrosion, are the possibilities of self-colouring, resistance to temperatures at least as high as 180° C., non-inflammability in the case of certain grades, and good electrical properties.

Ceramic Fibres into Paper

EXPERIMENTS into the properties of inorganic papers has taken on added significance in America where the National Research Laboratory is investigating the properties of paper made from ceramic fibre. While these experiments were continuing, the Carborundum Company announced the commercial availability of a type of fibre which the N.R.L. had been studying.

The fibre is called *Fiberfrax* and consists of aluminium silicate. The product is a fluffy white rock wool having fibres ranging from 1 in. in length down to 1/10,000 in. and in diameter from 10 microns to 0·1 microns.

First examinations showed that if the coarse fibres could be separated from the fine ones, a paper of high quality could be made from the remaining fibres. It had already been demonstrated that fine papers could be produced from fine fibred inorganic materials such as glass. Furthermore, the ceramic fibres might have additional advantages including freedom from boron, a melting-point considerably above that of the glass-fibre papers, and low electrical losses.

Inorganic papers have been used as filters and as electrical insulation. The high filtering efficiencies arising from the fineness of the fibres and the openness of the papers encouraged the exploitation of these papers. The electrical qualities arise from the excellent electrical properties of the base materials.

While glass fibres were a commercial reality when glass-fibre paper was first announced, ceramic fibres in the form of papermaker's pulp, or rather in the form suitable for papermaking, is not now a commercial reality. In the present form, the base material is a mixture of coarse and fine fibres. The coarse fibres are unsuited to papermaking because of their low dispersing qualities and because they include shot, slubs and pieces of unfibreized slag entrapped in the mass. In order to produce a suitable paper it is, therefore, necessary to fractionate out the part considered undesirable for papermaking and to employ the resulting fine fibres.

Preparation and Characteristics

It has been found that the separation of the fine fibres from the bulk of the *Fiberfrax* could be effected readily by circulating the entire mass in a chest and passing the slurry over a series of dams. Fractionation of the stock has resulted in a yield of 30 per cent. fine fibre, 8 per cent. balled fibre, and 62 per cent. shot, slubs, coarse white sand and unusable deposits. If this 30 per cent. of the stock is considered as papermaking pulp and sent through a decker for de-watering a quality product might be expected. It is interesting to note that the shot, slubs and other rejects

TABLE I.

Content and Analysis of Ceramic Fibre Paper

Content	*per cent.*
Ceramic Paper	100
Binder	0
Moisture	0·1
Chemical Analysis	
SiO_2	50
Al_2O_3	50

are not considered waste since they may be sent back to the blowing room and re-run into fibre without loss.

The fibre can be opened in equipment now considered standard for inorganic papermaking, namely a beater chest and Fourdrinier machine. No effort need be made to dry the paper since the material possesses more mechanical strength when wet than when dry and since it does not cockle when it dries in a roll form. The paper made at the experimental mill of the National Bureau of Standards (U.S.A.) was found to possess the qualities listed in Tables 1 and 2. It is apparent that the material is mechanically weak when it is composed only of ceramic fibres. However a glass fibre paper made from fibres of equivalent diameter would be just as weak.

Interpreting the air-resistance measurements in terms of fibre diameter indicates that the material averages 1 to 1·1 microns, or eight times greater than that reached lately in the field of glass fibres. The electrical properties of the paper are listed in Table 3 and are seen to be exceptionally fine; the losses are one-fourth those of kraft paper.

Since the scientists at N.R.L. had in mind the possibility of making paper from ceramic fibres, to demonstrate that paper could be made successfully on commercial or pilot plant equipment, and to encourage the producers to make finer fibres by changing their techniques and/or compositions, it appeared that some mechanically strong products were needed.

Two procedures were open: one involved the use of a filler such as bentonite and the other involved the beater addition of a resin to the furnish which would result in a paper possessing the strength due to the strengthening action of the resin. While the employment of a filler would lower the filtering efficiencies of the papers, it might result in an exploitable product capable of increasing the general usefulness of the inorganic fibres.

The Use of a Filler

The addition of a filler such as bentonite clay to the furnish will result in a much "tighter" paper having a higher density, lower porosity, and far greater resistance to the passage of air. On the other hand, it should be considerably stronger and

TABLE II.

Physical Properties of Ceramic Fibre Paper

Melting Point	1,560° C.
Thickness (in.)	0·024
Tensile strength (p.s.i.)	14
T.S. (50 per cent. moisture) (p.s.i.)	41
Density (g/cc)	0·206
Basic Weight	72·4
Uniformity	Excellent
Dirt Count	0
Bursting Strength (Mullen) (p.s.i.)	1
Tear Number (Elmendorf)	7
Absorptivity	High
Porosity (Gurley-sec)	22
Air Resistance (mm.-H_2O/mil.)	3·5

TABLE III.

Electrical Properties of Ceramic Fibre Paper.	
Dielectric Constant	
60 Cycles	1·08
1 kc	1·08
10 kc	1·08
Power Factor (per cent.)	
60 Cycles	0·02
1 kc	0·02
10 kc	0·02
Dielectric Loss Factor	
60 Cycles	0·0002
1 kc	0·0002
10 kc	0·0002

consequently of more use in the electrical field; besides this the product is totally inorganic.

The qualities of such a paper, successfully made on the paper machine of the National Bureau of Standards, is given in Table 4. A comparison of these qualities with those of Table 2 indicates that a tenfold increase in tensile strength has occurred. The air resistance of the sheet increased slightly, but no change of consequence was observed in the bursting strength or tear number.

This paper could be handled with ease on the paper machine, and it is also suitable for saturation with varnishes. The results of dipping this paper in varnishes to improve the mechanical and water-resistant characteristics are given in Table 5. It is apparent that the mechanical and electrical properties of this paper can be improved markedly by dipping in any one of these varnishes.

For application involving high temperatures, it is, of course, important to use a thermally stable varnish. On the other hand, for applications not requiring such rugged thermal cycling, but necessitating high mechanical strengths, the geons and acrylates should be satisfactory.

The Use of Resins

As mentioned, the alternative to the procedure just described is the use of resins in preparing ceramic fibre paper. The use of resins—and the qualities associated with each are listed in Table 6. Neither the percentage of solids employed nor the characteristics of the integrally sized products should be considered optimum since the shotgun technique was employed to demonstrate the opportunities for improvement available. In each case the resin was added to the beater, circulated with the stock of already opened ceramic pulp, and sent either over the Fourdrinier machine or fabricated into a laboratory handsheet.

An examination of Table 6 will show that mechanically strong sheets can be prepared by the addition of quantities of resins to the furnish. It is apparent that the strengths can be raised tenfold readily; and with

TABLE IV.

Composition	
Ceramic Fibre (per cent.)	80
Bentonite Clay (per cent.)	20
Physical Properties	
Thickness (in.)	0·0102
Density (g/cc)	0·298
Basic Weight	38·6
Tensile Strength (p.s.i.)	180
T.S. (wet, 50 per cent. moisture content)	285
Bursting Strength (Mullen) (p.s.i.)	1
Tear Number (Elmendorf)	6
Porosity (Gurley-sec)	1·2
Air Resistance (mm.-H_2O/mil.)	4·6

TABLE V.

Composition and Properties of Saturated Ceramic-Fibre Bentonite-Clay Paper.

Binder		Composition of Saturated Paper			Electrical Properties								
					Dielectric constant			Power factor (per cent.)			Loss factor		
Type	Solids per cent.	Ceramic Fibre per cent.	Binder per cent.	Bentonite per cent.	60–	1 kc	10 kc	60–	1 kc	10 kc	60–	1 kc	10 kc
Alkyd	54	18	75	4	4·7	5·0	5·0	16·5	0·9	0·7	0·78	0·04	0·03
Styrene	20	34	58	8	2·7	2·5	2·3	35·0	10·5	5·0	0·95	0·26	0·12
Forhalcresol	52	46	42	12	3·1	3·2	3·1	20·0	3·4	2·1	0·62	0·11	0·06
Vinyl	24	27	67	6	3·9	4·1	4·0	13·0	0·6	0·4	0·50	0·02	0·01
Polyester	100	26	68	6	4·1	4·2	4·0	19·0	2·0	1·5	0·82	0·09	0·06
Acrylate	20	20	75	5	3·7	3·7	3·7	14·5	1·6	1·0	0·54	0·06	0·04
Silicone	100	57	28	15	2·6	2·7	2·5	18·2	1·5	1·3	0·34	0·04	0·03

Binder	Chemical Properties		Physical Properties						
	Increase in moisture content* per cent.	Flammability†	Thickness (in.)	Tensile strength (p.s.i.)	Density (g/cc)	Basic weight‡	Bursting strength (Mullen) (p.s.i.)	Tear No. (Elmendorf)	Transparency (per cent.)
Alkyd	4·5	high	0·015	1420	0·810	154	17	32	50
Styrene	83	,,	0·013	984	0·703	115	17	160	10
Forhalcresol	49	,,	0·011	1544	0·370	54	7	48	—
Vinyl	40	,,	0·015	504	0·610	114	3	48	—
Polyester	25	,,	0·013	1420	0·771	123	14	32	—
Acrylate	59	,,	0·017	1052	0·861	190	35	128	—
Silicone	0	,,	0·013	1890	0·695	117	12	32	—

*After 24 hours immersion. †Weight of 500 sheets, 25 in. by 40 in. ‡Flammability after immersion in resin

TABLE VI.

Composition, Preparation and Properties of Integrally Sized Ceramic Fibre Paper.

Sizing Identity		*Preparation*			*Composition*		*Electrical Properties*								
							Dielectric constant			*Power factor (per cent.)*			*Loss factor*		
Type	*Solids Used*	*Diluent*	*Precipitant*	*Drying Conditions (° C./2hr.)*	*Ceramic Fibre (per cent.)*	*Binder (per cent.)*	60 –	1 kc	10 kc	60 –	1 kc	10 kc	60 –	1 kc	10 kc
Vinyl-Chloride	54	Water	Alum	165	52	48	2·31	2·33	2·32	2·70	1·95	1·95	0·06	0·04	0·04
Styrene	30	,,	,,	110	61	39	1·58	1·53	1·49	6·65	0·56	0·26	0·105	0·03	0·004
Acrylate	20	,,	,,	165	16	84	3·81	3·74	3·59	50·0	15·2	6·5	1·90	0·57	0·23
Phenolic	30	,,	H_2SO_4	130	92	8	1·55	1·59	1·57	8·9	0·2	0·1	0·137	0·003	0·002
Cellulose	6	,,	H_2SO_4	130	89	11	1·24	1·24	1·09	50	16·7	5·4	0·62	0·21	0·05
Fluro-Carbon	20	,,	Alum	316	42	58	1·79	1·78	1·77	2·85	0·23	0·16	0·05	0·003	0·002

Sizing	*Chemical*	*Properties*	*Physical Properties*							
	Increase in Moisture Content (per cent.)*	*Flammability*	*Thickness (in.)*	*Tensile strength (p.s.i.)*	*Density (g/cc)*	*Basis weight †*	*Bursting strength (Mullen) (p.s.i.)*	*Tear No. (Elmendorf)*	*Resistance mm-water mil.*	*Porosity (Gurley-sec)*
Vinyl Chloride	870	burns	0·004	325	0·353	17·9	2	41	17·5	5
Styrene	37	high	0·0025	355	0·334	16·6	2	7	4·0	2·5
Acrylate	3	high	0·004	500	0·753	56·5	5	39	11·0	2·0
Phenolic	418	burns	0·033	108	0·356	107·0	1	15	2·0	1·3
Cellulose	305	high	0·0115	512	0·370	39·2	3	12	5·0	1·2
Fluro-Carbon	0	none	0·0045	29	0·540	34·0	1	9	high	8·2

**After 24 hours immersion.* †*Weight of 500 sheets, 25 in. by 40 in.*

improvements in the techniques of precipitation and of handling the stocks, another fivefold increase seems possible.

The possibility of using the materials as covering for magnet wire seems highly possible but their performance in this respect will depend on the quality of the resin and the care taken in preparing the cleaner fibre. Again, such papers are capable of being saturated with the more common laminating and saturating varnishes and of being fabricated into panels having considerable strength.

Conclusions

At the present time there is commercially available a fibre-bearing product composed of aluminium silicate from which it is possible to extract a fibre sufficiently fine for fabricating into paper on Fourdrinier equipment. It is possible to incorporate various binders, fillers and saturants for enhancing the possibilities of using the item in plastic laminates and in magnet-wire covering applications. The fibre-bearing product requires further development before it can be introduced to the paper manufacturers with hope of seeing it exploited and experiments are continuing.

The fibre manufacturer must reduce the shot, slubs, and fibre clusters to a minimum by separating the fine fibres from the rock-wool type product. The fibres which are capable of being extracted must be finer than those presently available. This means the coarse fibres either must be reduced to a minimum in the blowing operation or they must be separated from the superfines in the separation and cleaning step. The commercial availability of aluminium silicate fibres in submicron diameters should be encouraged because they permit the manufacturer of synthetic inorganic papers having thermal stability of the order of 1,500° C., satisfactory electrical properties, and production techniques suited to large scale exploitation without the use of platinum (used in the production of E-glass fibres) which is in critical demand.

The future success of this development depends clearly on the willingness and ability of the fibre producers to supply papermakers with a cleaned, fine fibre ready to go into the beater.

Refractory Porcelain Tube Production

THE Office of Technical Services, United States Department of Commerce, operates a "Question and Answer Service" whereby technical questions on any industrial aspect may be submitted for investigation. Questions are submitted to experts and the answers made known to the trade generally and for no charge.

Recently a Belgium firm submitted a series of questions on refractory porcelain tubes. The inquirer manufactured porcelain tubes (mullite, zircon, silicon carbide, alumina, etc.), which vary from ¼ in. to 4 in. in dia. and may be as much as 5 ft. in length. These tubes are fired in a vertical position in refractory kilns at temperatures as high as 3,000° F. At these elevated temperatures there have been numerous difficulties and the following questions result:

1. How should the kiln be designed in order to obtain a uniform temperature?

2. What types of pyrometers should be used and where should they be located in the furnace in order to obtain the most accurate control of firing temperatures above 2,900° F?

3. What materials and processes could be used for hanging tubes which will be fired at temperatures above 2,900° F?

In reply, "Q & A" said that several manufacturers of porcelain tubes in the U.S. had been contacted but the companies were very reluctant to reveal technical information which they regarded as trade secrets. However, they did give some general information:

When a periodic type (batch kiln) is utilised for firing porcelain tubes it is suggested that the kiln be equipped with a downdraught and that at least three rows of burners, having at least three burners in each row, be distributed over the height of the kiln. In order further to ensure an even distribution of temperature in the kiln, the firing schedule

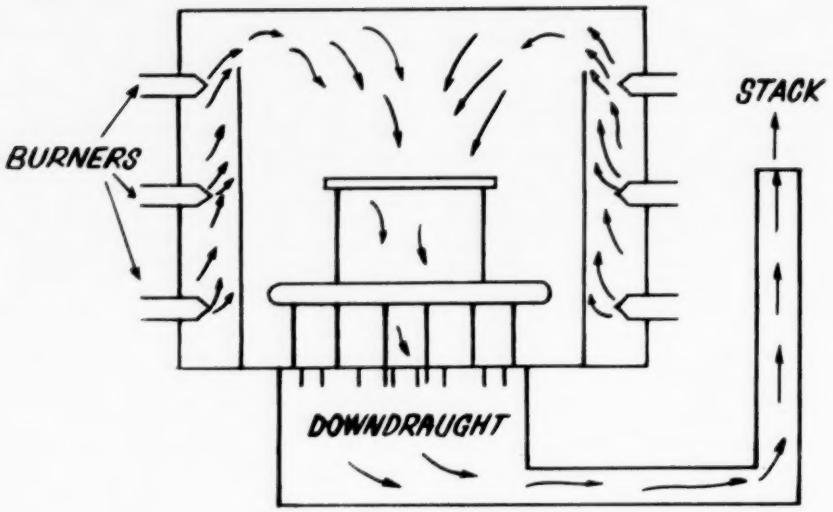


Fig. 1. Batch type kiln

should be slow (temperature should not be raised rapidly) and the porcelain tubes should be spaced some distance from each other.

For measuring temperatures to 2,900° F., platinum-platinum rhodium thermocouples should be used, but at higher temperatures optical pyrometers are required. For best control of temperature, three pyrometers should be used—one located on the floor of the kiln, another in the middle section, and a third at the top of the kiln.

When the refractory tubes are fired in a vertical position they are usually suspended inside a refractory cylinder of silicon carbide.

When the silicon carbide refractory cylinder is used to enclose the porcelain tubes, several methods are suggested for supporting the tubes. The first method utilises a silicon carbide disc containing a relatively large number of holes. This disc is placed on top of the cylinder after which the porcelain tubes are inserted in the holes. Each tube is supported in place by a collar or pin placed through the tube.

Another method utilises a number of silicon carbide I-beams placed close together so that they support the porcelain tubes. This method is preferred by one manufacturer because he found there was less tendency for the bars to crack than for the discs to crack. In a few instances, bars with tapered holes are used to support tubes which do not have collars (Method 3.). Coarse, fused alumina is inserted in the cone-shaped annulus between the tube and the refractory. The granular material wedges between the tube and refractory and thus supports the tube.

USE OF I-BEAMS

Fig. 2. Method 2

As a caution it should be mentioned that silicon carbide refractories are easily cracked at temperatures around 3,000° F. Also at these high temperatures there is a tendency for a small amount of silicon carbide to soften ("oozing of the glaze") and stain the porcelain tubes.

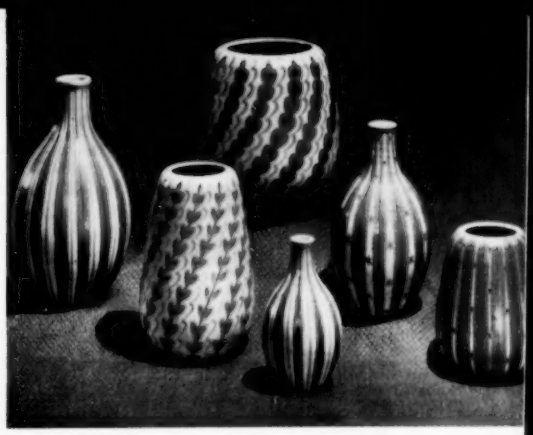
USE OF TAPERED HOLES

Fig. 3. Method 3

Poole Pottery

BY A

"CERAMICS" CORRESPONDENT



Hand-thrown carafes and vases with assorted new hand-painted decorations

POTTERY history is in the making at Poole, Dorset, where Carter, Stabler and Adams Ltd. are breaking away from a tradition and have embarked on what might be termed a trade mission to familiarise the public with new styles and colours.

Mr. Lucien Myers, the managing director, is an artist with original ideas, and he, together with M. A. B. Read, R.D.I., A.R.C.A., the chief designer, has been responsible for bringing about revolutionary changes in the last few years. Although he thinks the word contemporary is very much overworked and widely misunderstood, he has decided views about the sort of pottery required to meet present-day needs and tastes. He is out to smash what some critics have called the "shooting gallery" stuff and to replace it with pottery that is both æsthetic in design and colouring and at the same time suited to modern requirements.

Establishing a Tradition

Thirty-three years ago when the present makers of Poole pottery took over the tile works that had been founded on the quayside there a century before, they began making a type of ware that soon established a tradition, especially in the west country, and in the years between the wars Poole hand-painted pottery became almost a household word. Even today, Poole pottery to most people recalls matt white glaze with gay if not quite up-to-date decoration in greens and blues, rose pink, yellow and mauve. That sort of "Poole" is still favoured by a great many people in this country, but it is no longer sent to many of the countries overseas where it was once so popular.

Renaissance at Poole.

Today Poole is experiencing a renaissance. Transatlantic influence is seen in some of their present productions and designs for the future. Styles and patterns that were good enough for the 1920's are no longer tolerated, and in the next few years the "new idea" is expected to have a distinct bearing on the shape of things to come. From time to time the company will issue illustrated literature showing what these new pieces will be like. Some will be improvements on traditional designs; others will be still more advanced productions, but in the design room now there are many prototypes of things that have caused would-be buyers in this country and agents from abroad to clamour for a definite delivery date. One of these is a striking looking pot 2 ft. tall decorated in perpendicular lines of sienna and black. Another is a long boat shaped vase in white glaze with contrasting colour interior which are much in demand in New Zealand where floral decoration is regarded as a requisite art for every housewife.

Among the more recent hand-thrown shapes introduced are carafes and vases finished in one-colour egg-shell glaze with white inside, and wide-necked vases in various twin-tone finshes. A limited number of hand-thrown pots is also made with special glazes of Chinese type in rich blue and soft green over a red ground. Blue Moon cameo ware is another Poole speciality which has found wide favour in the limited number of overseas markets to which it has so far been offered. The firm hopes to introduce Blue Moon on the home market some time next year.

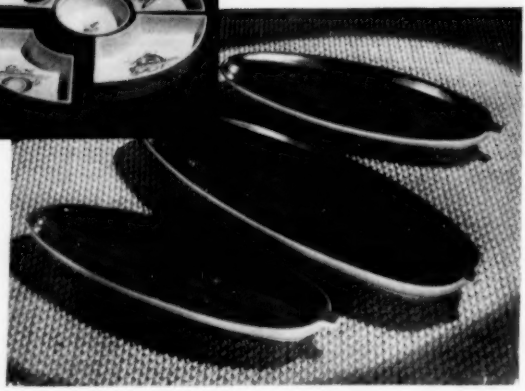
Growth from Studio Size

The slip-face Cameo ware is a post-war development at Poole that was introduced by the late John Adams, A.R.C.A. as a "production line" designed to fit appropriately into the new factory that was being built. During its pre-war career from 1921-1939 Poole Pottery had been in many ways a very large version of the studio pottery, employing rather more than 100 workers. There was no production

Left: A seven-piece fish set with hand-painted decoration designed by Truda Carter, A.R.C.A.

Right: Coffee ware in the "Streamline" shape with "Cameo" underglaze finish in Celadon green and white

Below: Cucumber dishes with "Twintone" finish



Above: Hors d'oeuvre dish and set finished in "Alpine" matt white glaze, with new hand-painted decorations in multi-colour, designed by Truda Carter, A.R.C.A.

programme in the sense that this is needed in a modern plant with a tunnel kiln requiring to be fed 24 hours a day. During the war years much of the factory lay dormant and as soon as the war ended a complete rebuilding scheme was decided on. It was then that the firm engaged Roy T. Holland, a highly qualified ceramic technician from Stoke-on-Trent, who although still a young man had had many years of experience in running an earthenware factory in the Potteries. It fell to his lot not only to play a leading part in the planning and equipping of the new factory, but also to train nearly all of the 160 operatives now working there—for only a handful of the skilled potters of pre-war days were still available at Poole. His task also involved the setting up of co-ordinated production groups at each stage of manufacture to ensure a smooth flow of ware for the tunnel kiln and the organisation of each type of work on a piecework basis to ensure a fully economical production without any sacrifice of quality and finish.

The changeover from intermittent firing in bottle kilns to firing in the electric tunnel involved many technical innovations, including reconstituting the basic body material as well as all the glazes and colours used.

This has meant some years of steady work that has gone forward by trial and error methods on the part of the laboratory staff under Mr. Holland's supervision. The laboratory also plays a vital part in the production of large numbers of trial glazes, slips and colours which are continually being considered at the regular meetings of the Design Committee where new shapes, patterns and glazes are discussed and tried out. There are many new ideas being worked on for vase shapes and patterns that have a character of their own and are said to be quite different from anything else that one can see in England.

Utility of Design important

Utilitarian ware is, however, in the forefront of the Poole company's programme, and in this direction the designers have given full play to their imagination in meeting contemporary tastes. American and Canadian influences are apparent in the streamline shapes and twintone finish of their tableware, with coupe plates and chop dishes, Cameo dinner, tea and coffee ware in Celadon green with interiors, knobs and handles in ivory white. The coupe plate, thinks Mr. Myers, looks like superseding the traditional rim plate though some people, it is admitted, refuse to be stampeded into accepting this supposed New World innovation, which really originated in China many centuries ago.

All Ware Hand-Painted

No "transfers" are used at Poole. Everything is hand-painted, and it is claimed that there is more hand work done here than in any other commercial pottery in England. A school of painting has been established where girls are taught the art of colour application under an expert teacher, and there are more would-be pupils than the local industry can take on. It is claimed also that Poole is the cleanest pottery in England, and that may well be so, for the rebuilding of the works on the quayside was completed as recently as 1949.

Production has been planned on the modern flow-line system, and time and motion study which is in practice here helps the worker at every stage and at the same time speeds up output, which has been greatly accelerated since the restrictions on decorated ware were were lifted two years ago, so that now supplies lag behind demand. Mr. Myers thinks this may not be a bad thing because when he was in the United States recently he found that when certain types of pottery were in short supply customers were willing to wait for them, but when supplies became plentiful demand fell off.

So far no mechanical means have been adopted for applying patterns. In-glaze technique is used and all the glazes are applied by spray gun which gives a very much finer finish than the more usual method of dipping, and also makes possible effects not otherwise obtainable. The Gibbons electric kiln is 97 ft. 6 in. long.

Research Laboratory Available

There is a well-equipped laboratory where research is carried out into every aspect of glazes, colours, slips and body materials with a view to improving continuously the quality of the products.

For a comparatively new pottery established in a district where there was previously no traditional or Staffordshire experience to draw on, Poole has made remarkable strides and has entered overseas markets, including North and South America with considerable success. In the near future, extensions are to be made to the existing premises to meet a growing demand; but, says Mr. Myers, good taste will never be sacrificed for mass production.

Following the interval of the war years, and the period of restriction, Poole has assumed a distinctive role in ceramic design, and with the emphasis now being placed on new shapes and decorations looks like setting a precedent for the future.

Stoneware for Packaging Exhibition

(By a "Ceramics" Correspondent)

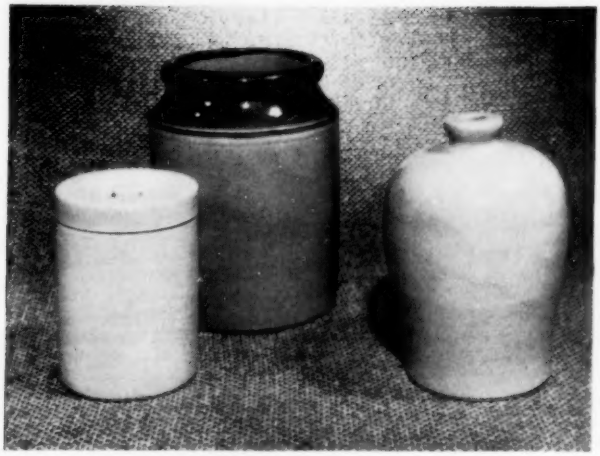
ENCOURAGED by the increasing interest being shown in stoneware as a packaging medium, leading manufacturers in the United Kingdom are to stage a joint display of their wares at the forthcoming Packaging Exhibition to be held at Olympia, London, in January next. It is being organised under the auspices of The National Federation of The General Stoneware Industry.

Industry Seeks Publicity

As represented by members of the British Stoneware Manufacturers' Association, the stoneware industry has exhibited ceramic containers at one or two recent Packaging Exhibitions and on each successive occasion the displays have evoked a marked increase of interest. It has consequently been decided that the products of all the principal manufacturers of stoneware in the United Kingdom be jointly displayed on the next occasion.

Intended to give added appeal to Britain's exports of food, drink, cosmetics, tobacco, confectionery, etc., this wide range of products will all be made from the highly vitrified, non-porous type of stoneware ceramic material, which is characterised by great strength and durability. They are made from scientifically-controlled mixture of specially selected English clays and other ingredients fired at about 1,250° C. to ensure non-porosity. So tough is this material that its compression strength

A group of interesting stoneware containers from among the many that will be displayed at the forthcoming Packaging Exhibition.



In contrast with the well - established cream and brown glazes such as are used in the jar in the middle of the group, glazes are available in a wide range of pastel and deeper colours

is equal to that of grey cast iron, and, stronger than any other ceramic material, would, handled with reasonable care, keep free from ill-effect from rust, damp, changes of temperature or other climatic conditions for centuries, if need be.

Advantages for Packaging

As a packaging medium stoneware has a number of other advantages. No other packaging material offers the same universal resistance to corrosion. It is acid resisting through and through and does not depend upon its glaze for this quality. Apart from hydrofluoric acid and hot caustic alkalis no chemical will affect it.

Stoneware is an inert material and does not affect the taste, colour or smell of the products packed in it; nor, on the other hand, is it affected by them. This is a particularly important consideration where the packaging of food, cosmetics, pharmaceuticals and chemicals is concerned.

Endless Variety

Thanks to the nature of the raw materials used, stoneware containers can be made in an astonishing variety of shapes and in sizes ranging from a few ounces to several hundred gallons. On a recent visit to the Federation's showrooms in London the writer had the opportunity of seeing a selection of these containers which covered a wide range of uses. There were containers for caviare, honey, marmalade, jams, mincemeat, Christmas puddings, biscuits, pickles, mustard, vinegar, essences, etc., for the food industries; attractively designed mugs, tankards, egg cups, which could be wrapped with cellophane and used to contain chocolates, Easter eggs, confectionery and similar products; delightfully shaped flagons, jars, barrelettes and other containers for wines, spirits, liqueurs, cider, etc.; containers for perfumes, bath salts, cosmetics, face creams, shaving creams and allied products and special containers for pharmaceutical and chemical products, for which wicker cases can be supplied for transportation purposes. There were also air-tight jars for biscuits, tobacco and other products.

Hygienic and Attractive

The smooth glazed inner and outer surfaces of stoneware containers facilitate quick and thorough cleaning and ensure a high standard of hygiene. At the same time a well designed stoneware container with an attractive decorative motif in either the cream and brown glazes or in the variety of pastel or stronger shades of yellow, blue, green and pink glazes now available can be very appealing and enhance the prestige of the product it contains.

A Lining Machine

INTEREST attaches to a small, hand-operated lining machine, an illustration of which appears on this page. Produced by the Cyclo Gear Co. of Birmingham, manufacturers of lining devices, the machine is designed for use with an adaptation of the company's standard lining instrument. When seen in operation by our representative the machine was shown to be fully capable of "lining" holloware of various sizes.

As will be seen, the machine comprises a bedplate on which are mounted a headstock and tailstock, together with a saddle on which the lining tool is held during the lining operation. The machine is hand driven by turning the small hand wheel which is to be seen at the bottom left of the photograph.

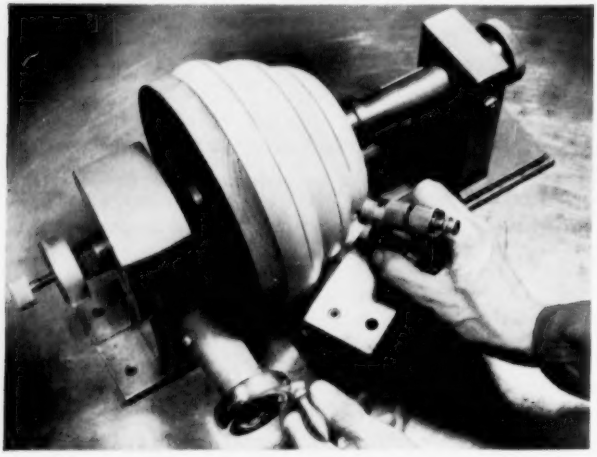
The hand wheel drives the tapered headstock spindle on which is mounted a faceplate. It is here that cups, bowls, etc., are fixed during the lining operation. In operation the vessel to be lined is centralised internally on the faceplate by means of four spring-loaded fibre pads which are actuated through the tapered central spindle, which is fitted with means of quick release. Additional means of holding the vessel in position are provided by a rubber pad which is mounted at the end of the tailstock spindle. The pad is brought to bear on the base of the vessel to be lined and is locked in position during lining by use of an adjustable cam locking device.

Lines are made by use of a modification of the standard Cyclo lining instrument. This device consists of a cylindrical lining box, with colour container, through which there runs a wheel which deposits lining fluid from its periphery, giving single or double lines in a range of thicknesses.

Operation

In operation the article to be lined is placed in position on the faceplate and is centralised by use of the spring-loaded centralising blocks. With the vessel in position, the rubber padded holding device is brought to bear on the foot of the article and is locked in position. The faceplate is then slowly revolved, the turning device being operated by the left hand. The lining instrument is then applied by the right hand and the lining medium is deposited on the vessel as required.

The machine, we are informed, has been designed for use by the small producer, particularly where an accurate, flexible means of lining is required, and where skilled hand liners are not available.



The lining machine in operation

HYDROSTATIC DUST COLLECTOR

A new type of Dallow Lambert dust collector has been added to the present range of patent Multiswirl models.

Previously available in the MSE series and applied in the main as an individual unit for fettling booths, double end polishers and grinders, the new series ME is available to handle large volumes of air and heavy dust concentrations. This new series, employing the Dallow Lambert patent hydrostatic cross tube element, scrubs dust laden air in either water or oil.

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Multiswirl collectors are manufactured in a range of sizes to suit all applications from 200 to 100,000 c.f.m., the larger sizes being fitted with multiple cross tube elements and automatic sludge disposal. In the case of soluble dusts where no sludge is formed it is usual to arrange for drainage, continuous or intermittent, either to waste or to a reclamation process, according to the value of the dust.

A hand-controlled valve allows for sludge removal on this model

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The British Ceramic Society

ABSTRACTS of the three papers which appeared in the Transactions of the British Ceramic Society for August, 1954, are printed below.

Note on the Relationship between Bulk Density and Thermal Conductivity in Refractory Insulating Bricks. by K. W. Cowling, A. Elliott, and W. T. Hale.

The authors have analysed the records of bulk-density and thermal-conductivity routine production control tests on two types of refractory insulating bricks. Of the total variation in conductivity, 50 per cent. in one case and 22 per cent. in the other was due to the density factor. It is concluded that a conductivity estimation from density alone on a single brick is likely to be highly inaccurate, but that an average figure based on the average density of, say, nine bricks would be accurate enough for most practical purposes. It is stressed that the results reported apply only to these two particular brands of brick made from the same raw materials by essentially the same process.

Practical and Theoretical Aspects of the Hot Pressing of Refractory Oxides. by P. Murray, E. P. Rogers, and A. E. Williams.

The hot-pressing characteristics of a number of refractory oxides are described and related to the applied pressure and the conditions of initial preparation of the powders. The method is particularly suitable when "active" or uncalcined powders of extremely fine particle size are used since the high surface-energy characteristics of these powders can be utilised without the fabrication difficulties (high shrinkage and cracking tendency) encountered in the conventional sintering methods.

The process is also discussed from a theoretical standpoint in relation to the plastic flow theories of sintering; equations are derived from the Shuttleworth-Mackenzie theory relating the end-point density with applied pressure, surface tension, yield stress, viscosity, and the number of closed pores per unit volume. The predictions of these equations in relation to the effect of pressure on rates of densification and the final bulk densities achieved are in accord with practice.

The Dissociation of Carbon Monoxide by Iron Compounds. by W. R. Davis and G. R. Rigby.

An investigation has been made into the dissociation of carbon monoxide in contact with iron compounds with a view to establishing the possible nature and mode of action of the catalyst. Tests have shown that, for the reaction to occur, the iron compound must be readily reducible to metallic iron. X-ray powder photographs have shown the presence of iron carbide as an end-product in all cases. Tests on sintered iron compounds have indicated that the reaction is essentially an adsorption catalysis, since the composition of the attacked material does not vary from point to point with the specimen. An hypothesis has been formed as to the nature of the catalyst.

B.C.S. ANNUAL GENERAL MEETINGS

THE annual general meeting of the British Ceramic Society was held at the North Staffordshire Technical College on Monday, 20th September, 1954, the retiring president, Dr. A. T. Green, O.B.E., D.Sc., F.R.I.C., being in the chair supported by Mr. H. Clews, the hon. general secretary, and the other officers of the Society.

After reading and approving the minutes the election of officers was proceeded with as follows:

President: Mr. Richmond Douglas; *Hon. Gen. Sec.*: Dr .A. T. Green, O.B.E.; *Hon. Librarian*: Dr. H. W. Webb, O.B.E.; *Hon. Editor*: Mr. G. Stewart; *Hon. Treasurer*: Mr. T. Collinson; *Hon. Sec., Pottery Section*: Dr. W. L. German; *Hon. Sec., Refractory Materials Section*: Dr. G. R. Rigby; *Hon. Sec. Building Materials Section*: Mr. F. Clews; *Hon. Sec., Basic Science Group*: Mr. A. Smith.

Council Members (Elected by Pottery Section): Messrs. A. G. Ellis, J. A. Johnson, L. Bullin, A. J. Dale; *(Elected by Refractory Materials Section):* Messrs. R. Douglas *(President)*, C. L. F. Threlfall, F. West *(Elected by Building Materials Section);* Messrs. E. Simpson, A. J. C. Watts and M. S. Whitehouse, M.B.E.

Messrs. Bourner, Bullock and Co. were elected auditors.

The retiring president invested the president-elect, Mr. R. Douglas with the jewel of the office and congratulated him

on his election. In thanking the members, the new president referred to the services rendered to the Society over a period of 30 years by Dr. A. T. Green, and moved that he be made an Honorary Fellow of the Society. This was carried with acclamation. Dr. Green briefly thanked the members for the honour conferred on him.

The hon. general secretary read the report of the Council for the year which disclosed an increase in membership, considerable increases in the sales of the Society's *Transactions*, and a very healthy financial position.

The officers were thanked for their work which had led to such a remarkable improvement in the Society's general position in recent years.

B.C.S. Pottery Section. Annual General Meeting

The annual general meeting of the Pottery Section was held on 20th September, 1954, at the North Staffordshire Technical College, Dr. A. T. Green being in the chair. The minutes of the previous A.G.M. held on 28th September, 1953, were read and signed.

The following section officers were elected:

Chairman: Dr. A. T. Green; *Hon. Section Sec.:* Dr. W. L. German; *Elected Vice-President* (to serve for three years); Mr. A. Dinsdale; *Members of Pottery Section Council (to serve for three years):* Mr. P. Tillwright, Mr. J. Plant, Mr. J. A. Johnson; *Representatives on the General Council of the Society:* Messrs. A. G. Ellis, J. A. Johnson, L. Bullin, A. J. Dale.

P. Curnock.—In September, Mr. Percy Curnock, one of the foremost ceramic artists in the country, who has designed Royal Doulton china for nearly seventy years, retired at the age of eighty-two. Tributes to his services were paid at a presentation made to him at the Royal Doulton Potteries, Burslem. Distinguished as a floral and scenic painter, his unrivalled service to the pottery industry was recognised earlier this year by the award of the M.B.E.

J. H. Weatherby.—We regret to record the death, which occurred in September while holidaying with his family at Rhyl, North Wales, of Mr. John Henry Weatherby, chairman of J. H. Weatherby & Sons Ltd., the Hanley earthenware manufacturers. Mr. Weatherby, who was eighty-five and lived at Alsager, Cheshire, was a well-known figure in the pottery industry and in Methodist circles. With his father, he founded the Falcon Pottery, High Street, Hanley, in 1891, and attended the pottery almost daily until he was eighty-two.

R. Douglas.—Mr. Richmond Douglas, Scottish firebrick manufacturer, who was elected President at the annual meeting of the British Ceramic Society, at the North Staffordshire Technical College, on 20th September, has been prominent in the activities of the National Federation of Clay Industries and the Scottish Council.

In his presidential address, Mr. Douglas dealt with the refractories industry in Scotland and some of the outstanding personalities connected with it.

M. Dudley Thompson.—Rapid Magnetic Machines Ltd. announce that one of their directors, Mr. M. Dudley Thompson has just completed forty years with the company. With his late father, who founded the company about forty years ago, Mr. Thompson assisted in pioneering the industrial application of magnetic equipment not only in this country but also abroad.

In his less busy moments, Mr. Thompson likes gardening and travelling.

Mr. M. Dudley Thompson

Gas Consumption in Stoke.—The ever-increasing quantities of gas and electricity which are being supplied for firing purposes to the Staffordshire pottery industry are playing an important part in smoke abatement in the Potteries district.

The Stoke-on-Trent gas undertaking, as a consequence, has grown to one of the largest in the country. In 1933, the total gas used for pottery firing was just over 36¼ million c. ft. By 1947 it had jumped to 2,156 million c. ft., and the present yearly consumption is estimated at 5,500 million c. ft.

P. J. Dickins.—In order to promote the fullest possible liaison between the Midlands Electricity Board and the pottery industry, and to encourage the future development of electrical applications in the field of ceramics, Mr. P. J. Dickins, M.Inst.B.E., has been appointed ceramics engineer in the North Staffs Sub-Area.

Mr. Dickins, who is thirty-nine years of age, was educated at Alleynes Grammar School, Stone, Stafford Technical College and the North Staffs. Technical College. Subsequently he obtained industrial experience in the English Electric Co.'s Works at Stafford, followed by appointments with the British Ceramic Services Co. and Gibbons Bros. Ltd. of Dudley, where he was associated with the design and erection of kilns. This was followed by appointments with H. and R. Johnson Ltd. and Booth and Colclough, Ridgways and Adderleys where he was associated with the day-to-day maintenance and running of kilns and all types of pottery machinery and plant.

During the last war, Mr. Dickins served with the Royal Engineers, both at home and in France and Belgium.

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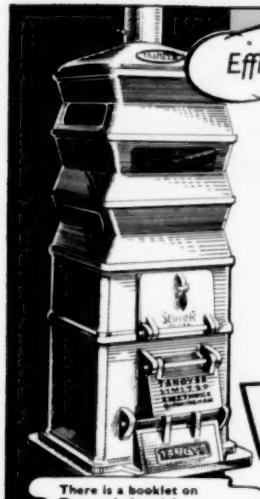

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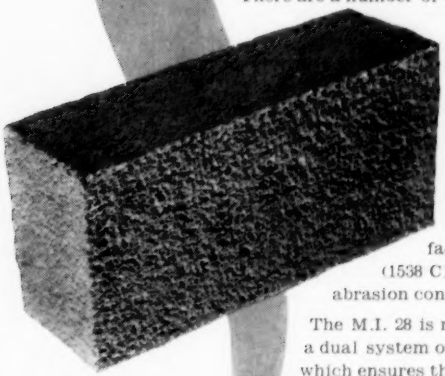
That depends on the furnace . . . But it also depends on the weight of the roof.

Cut the weight of the refractories by two thirds and (on a large roof at least) you can cut the steel structure by the same amount or more. Lightening the brickwork cheapens the whole furnace structure. That in itself is a good enough reason for using M.I.28 refractories.



There are a number of other reasons equally good. The M.I.28 is a low storage high-temperature insulating refractory. It requires only a fraction of the heat (and fuel) required by ordinary firebrick to bring it up to temperature. Batch type furnaces heat up rapidly, heating cycles are shortened and output per furnace goes up. It can be used as the sole furnace lining at face temperatures up to 2800 F (1538 C) except under heavy slagging or abrasion conditions.

The M.I. 28 is made on continuous plant under a dual system of process control and inspection which ensures that within very narrow limits every brick is as good as the best.

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